L-PRO 4000

Transmission Line Protection Relay

User Manual

Version 2.5 Rev 0

Preface

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Using This Guide

This User Manual describes the installation and operation of the L-PRO line protection relay. It is intended to support the first time user and clarify the details of the equipment.

The manual uses a number of conventions to denote special information:

Example	Describes
Start>Settings>Control Panel	Choose the Control Panel submenu in the Settings submenu on the Start menu.
Right-click	Click the right mouse button.
Recordings	Menu items and tabs are shown in italics.
Service	User input or keystrokes are shown in bold.
Text boxes similar to this one	Relate important notes and information.
..	Indicates more screens.
▶	Indicates further drop-down menu, click to display list.
	Indicates a warning.

Acronyms

ASG - Active Setting Group

CCVT - Capacitance Coupled Voltage Transformer
CID - file extension (.CID) for Configured IED Description
CS - Control Switch
CT - Current Transformer

DCB - Directional Comparison Blocking
DCE - Data Communication Equipment
DIB - Digital Input Board
DIGIO - Digital Input/Output Board
DMDA - Dead Main Dead Aux
DMLA - Dead Main Live Aux
DSP - Digital signal processor
DTE - Data Terminal Equipment

GFPCB - Graphics Front Panel Comm Board
GFPDB - Graphics Front Panel Display Board
GPS - Global Positioning System

HMI - Human Machine Interface

ICD - file extension (.ICD) for IED Capability Description
IEC - International Electrotechnical Commission
IED - Intelligent Electronic Device
IP - Internet Protocol (IP) address
IRIG-B - Inter-range instrumentation group time codes

LE- Load Encroachment
LED - Light-emitting Diode
LHS - Left Hand Side
LMDA - Live Main Dead Aux

LOCB - L-PRO Output Contact Board

LOCBH - L-PRO Output Contact Board - HCFI

LOP - Loss of Potential

MPB - Main Processor Board

MPC - Micro Processor

PLC - Programmable Logic Controller

POTT - Permissive Over-reaching Transfer Trip

PUTT - Permissive Under-reaching Transfer Trip

PT - Permissive Trip

RAIB -Relay AC Analog Input Board

RASB -Relay AC Analog Sensor Boards

RHS - Right Hand Side

RPCB - Rear Panel Comm Board

RTOS - Real Time Operating System

RTU - Remote Terminal Unit

SCADA - Supervisory Control And Data Acquisition

SG - Setting Group

SIR ratio - Source Impedance Ratio

SOTF - Switch-On-To-Fault

TT - Transfer Trip

TUI - Terminal User Interface

UI - User Interface

VI - Virtual Input

WI - Weak Infeed

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Version Compatibility

This chart indicates the versions of Offliner Settings, RecordBase View and the User Manual which are compatible with different versions of L-PRO firmware.

RecordBase View and Offliner Settings are backward compatible with all earlier versions of records and setting files. Use RecordBase View to view records produced by any version of L-PRO firmware and Offliner Settings can create and edit older setting file versions.

Minor releases (designated with a letter suffix - e.g. v3.1a) maintain the same compatibility as their base version. For example. L-PRO firmware v3.1c and Offliner Settings v3.1a are compatible.

L-PRO 4000 Firmware/Software Compatibility Guide

L-PRO Firmware	RCP Version	Setting Version	Compatible Offliner Settings	ICD File Version
v2.5	v2.5 or greater	407	v2.6 or greater	3.0
v2.4a	v2.4 or greater	406	v2.5 or greater	2.0
v2.3	v2.1 or greater	404	v2.3 or greater	2.0
v2.2	v2.1 or greater	404	v2.3 or greater	2.0
v2.1a/b	v1.3 or greater	403	v2.1 or greater	0.0
v2.1	v1.2 or greater	403	v2.1 or greater	n/a
v2.0	v1.0 or greater	402	v2.0 or greater	n/a
v1.0	n/a	401	v1.0 or greater	n/a

Please contact ERLPhase Customer Service for complete Revision History.

PC System Requirements and Software Installation

Hardware

The minimum hardware requirements are:

- 1 GHz processor
- 2 GB RAM
- 20 GB available hard disk space
- USB port
- Serial communication port

Operating System

The following software must be installed and functional prior to installing the applications:

- Microsoft Windows XP Professional Service Pack 3 or
- Microsoft Windows 7 Professional Service Pack 1

Relay Control Panel requires Windows XP SP3 (it will not work on earlier versions of Windows).

Software Installation

The CD-ROM contains software and the User Manual for the L-PRO Transmission Line Protection Relay.

Software is installed directly from the CD-ROM to a Windows PC. Alternatively, create installation diskettes to install software on computers without a CD-ROM drive.

The CD-ROM contains the following:

- L-PRO Offliner Settings: Offliner settings program for the relay
- L-PRO Firmware: Firmware and installation instructions
- L-PRO User Manual: L-PRO manual in PDF format
- L-PRO Function Logic Diagram: diagram in PDF format
- Relay Control Panel: software
- Relay Control Panel User Manual: manual in PDF format
- USB Driver

To Install Software on the Computer

Insert the CD-ROM in the drive. The CD-ROM should open automatically. If the CD-ROM does not open automatically, go to Windows Explorer and find the CD-ROM (usually on D drive). Open the ERLPhase.exe file to launch the CD-ROM.

To install the software on the computer, click the desired item on the screen. The installation program launches automatically. Installation may take a few minutes to start.

To view the L-PRO User Manual the user must have Adobe Acrobat on the computer. If a copy is needed, download a copy at www.adobe.com.

Anti-virus/Anti-spyware Software

If an anti-virus/anti-spyware software on your local system identifies any of the ERLPhase applications as a “potential threat”, it will be necessary to configure your anti-virus/anti-software to classify it as “safe” for its proper operation. Please consult the appropriate anti-virus/anti-spyware software documentation to determine the relevant procedure.

1 Overview

1.1 Introduction

The L-PRO 4000 provides easy-to-use, state-of-the-art comprehensive distance and directional line protection for medium to extra high voltage transmission lines using communication-based schemes. It provides control, automation, metering, monitoring, fault oscillography, dynamic swing recording, event logging with advanced communications in a flexible cost effective package.

The primary protection is line protection with 5 zones of phase and ground distance functions – user-defined Mho or Quadrilateral shapes and communications based schemes (i.e. teleprotection or pilot schemes).

To provide a complete package of protection and control the relay supplies other functions such as:

- 1.0 to 1.3 cycle operation at 80% reach, ideal for EHV transmission line applications
- Ring bus capability – breaker failure and individual breaker monitoring
- 4-shot recloser with dead line/dead bus control and sync check
- Single pole and three pole trip and reclose
- 24 statements of ProLogic addresses special protection needs
- Power Swing Blocking / Tripping
- Load Encroachment
- Switch-On-To-Fault function
- VT Supervision function
- CT Supervision function
- Over / Under Voltage functions
- 8 Setting Groups (SG) with setting group logic
- Back up Directional overcurrent and earth fault protection
- Over / Under / Rate of change of frequency devices

Relay Control Panel (RCP) is the Windows graphical user interface software tool provided with all 4000 series and higher (new generation) ERL relays to communicate, retrieve and manage records, event logs, fault logs, manage settings (identification, protection, SCADA etc.,), display real time metering values, view, analyze, and export records in COMTRADE format.

In addition to the protection functions the relay provides fault recording (96 samples/cycle) to analyze faults and to review the operation of the overall protection scheme. The relay also has low speed swing recording which can be used to analyze system stability. The triggers for fault recording are established

by programming the output matrix and allowing any internal relay function or any external input or any GOOSE messaging input to initiate recording.

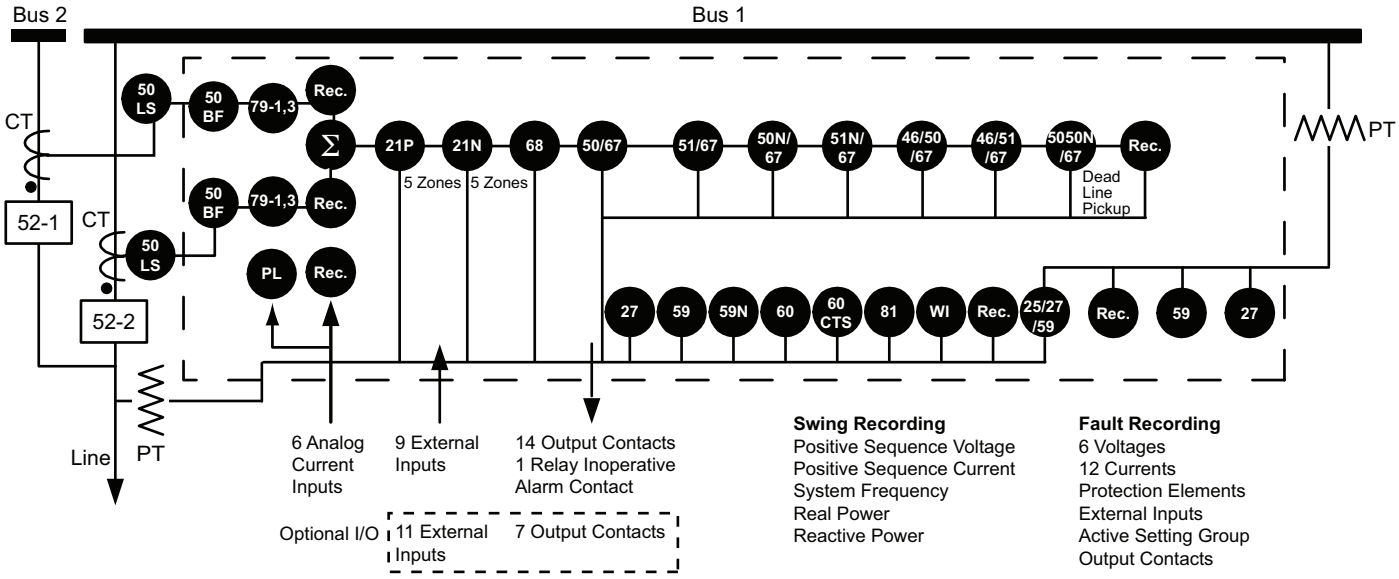


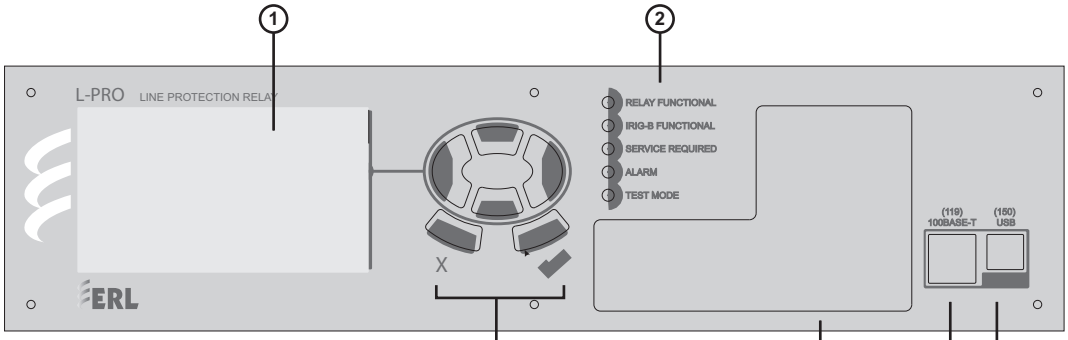
Figure 1.1: L-PRO Relay Function Line Diagram

50LS: Low set overcurrent

PL: ProLogic

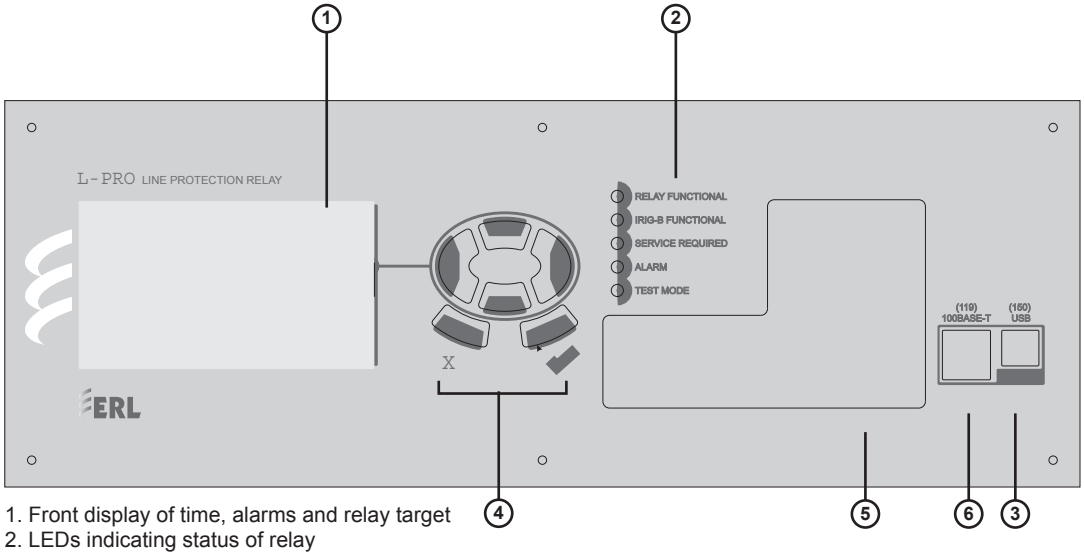
WI: Weak infeed

1.2 Front View



1. Front display of time, alarms and relay target
2. LEDs indicating status of relay
3. USB Port 150 for maintenance interface
4. Push buttons to manipulate information on settings, display and to clear targets
5. 11 Target Programmable LEDs
6. Ethernet Port 119

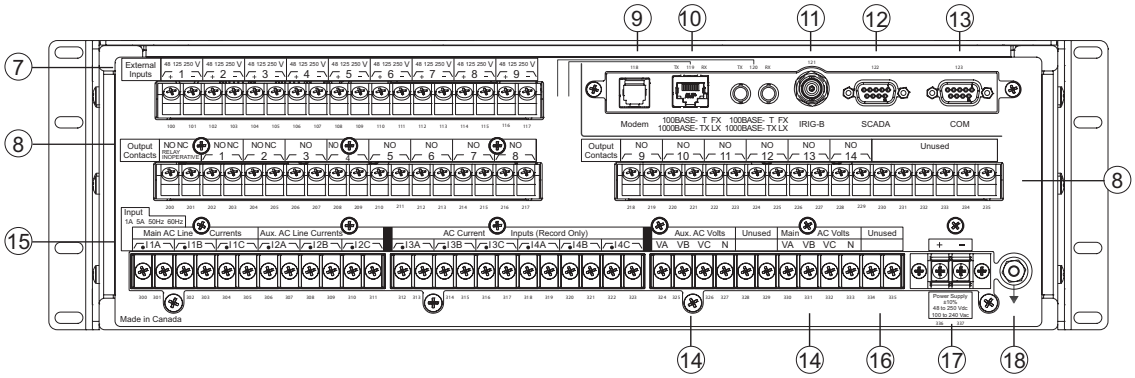
Figure 1.2: L-PRO Relay Front View (3U)



1. Front display of time, alarms and relay target
2. LEDs indicating status of relay
3. USB Port 150 for maintenance interface
4. Push buttons to manipulate information on settings, display and to clear targets
5. 11 Target Programmable LEDs
6. Ethernet Port 119

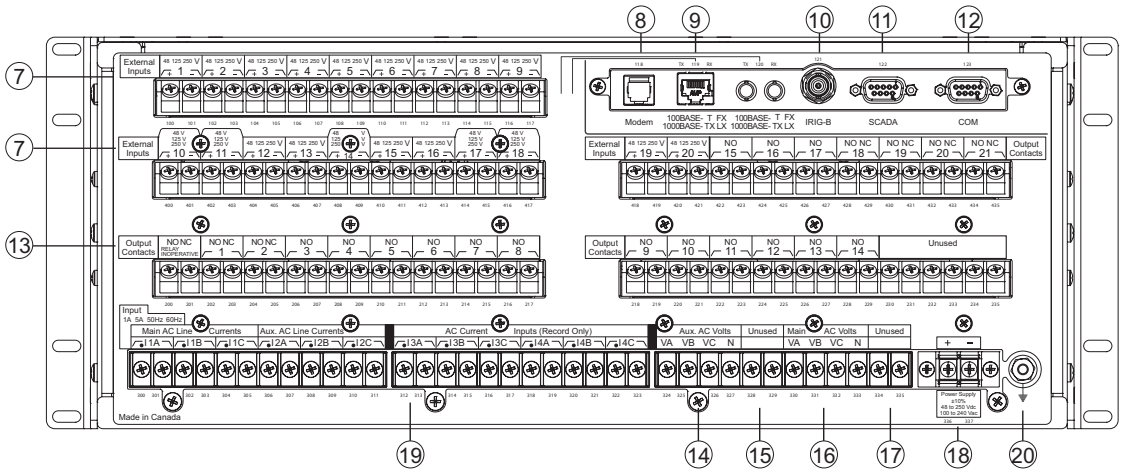
Figure 1.3: L-PRO Relay Front View (4U)

1.3 Rear View



7. Ports 100-117: 9 External Programmable Inputs
8. Ports 200-201: Relay inoperative contact
   Ports 202-229: 14 programmable output contacts
   Ports 230-235: Unused
9. Port 118: Internal modem
10. Port 119-120: 100BASE-T or 100BASE-FX Ethernet Ports
11. Port 121: External clock, IRIG-B modulated or unmodulated
12. Port 122: SCADA
13. Port 123: Direct/Modem RS-232 Port
14. Ports 324-327, 330-333: AC voltage inputs
15. Ports 300-323: AC current inputs
16. Ports 230-235, 328, 329, 334, 335: Unused
17. Ports 336-337: Power supply
18. Port with GND symbol: Chassis Ground

Figure 1.4: L-PRO Relay Rear View - 3U/3A (previously 3U)



7. Ports 100-117, 400-421: 20 External Programmable Inputs
8. Port 118: Internal modem
9. Port 119-120: 100BASE-T or 100BASE-FX Ethernet Ports
10. Port 121: External clock, IRIG-B modulated or unmodulated
11. Port 122: SCADA
12. Port 123: Direct/Modem RS-232 Port
13. Port 200-229, 422-435: 21 programmable output contacts
14. Port 324-327: AC voltage inputs
15. Port 328-329: unused
16. Port 330-333: AC voltage inputs
17. Port 334-335: unused
18. Port 336-337: Power supply
19. Port 300-323: AC current inputs
20. Port with GND symbol: Case ground

Figure 1.5: L-PRO Relay Rear View (4U)

AC Current and Voltage Inputs

The relay is provided with terminal blocks for up to 12 ac currents and 6 phase-to-neutral voltages.

Each of the current input circuits has polarity (•) marks.

A complete schematic of current and voltage circuits is shown, for details see "AC Schematic Drawings" in Appendix I and "DC Schematic Drawings" in Appendix J.

External Inputs

The relay contains 9 (3U) or 20 (4U) programmable external inputs.

Output Relay Contacts

The relay has 14 (3U) or 21 (4U) programmable relay contacts.

Relay Inoperative Alarm Output

If the relay becomes inoperative, then the Relay Inoperative Alarm output contact closes and all tripping functions are blocked.

1.4 Model Options/Ordering

The relay is available as a horizontal mount, for details see “Mechanical Drawings” in Appendix G.

The relay is available with an optional internal modem card.

The two rear Ethernet ports can be ordered as one copper-one optical port or both optical ports or both copper ports. These ports on the rear panel are available as either 100BASE-T (RJ-45) or 100BASE-FX (optical ST).

The Current Transformer (CT) inputs are 1 A nominal or 5 A nominal.

The external inputs are 48, 110/125 or 220/250 Vdc.

The system base frequency is either 50 Hz or 60 Hz.

The L-PRO 4000 is available in a standard 3U/3A (previously 3U) rack model or as 4U/4A (previously 4U) model with an optional I/O board as described above.

All of the above options must be specified at the time of ordering.

2 Setup and Communications

2.1 Introduction

This chapter discusses setting up and communicating with the relay including the following:

- Power supply
- Inter-Range Instrumentation Group time codes (IRIG-B) time input
- Communicating with the relay using a network link, a direct serial link and a modem link (internal, external)
- Using Relay C
- ontrol Panel to access the relay's user interface
- Using HyperTerminal to access the relay's maintenance menu
- Setting the Baud rate
- Accessing the relay's Supervisory Control And Data Acquisition (SCADA) services

2.2 Power Supply

A wide range power supply is standard. The nominal operating range is 48 – 250 Vdc, 100 – 240 Vac, +/-10%, 50/60 Hz. To protect against a possible short circuit in the supply use an inline fuse or circuit breaker with a 5 A rating. Ensure that the chassis is grounded for proper operation and safety.

There are no power switches on the relay. When the power supply is connected, the relay starts its initialization process. See "Using the IED (Getting Started)" on page 3-1 for the start up process details.

Case Grounding

Ground the relay to the station ground using the case-grounding terminal at the back of the relay, for details see Figure 1.5: L-PRO Relay Rear View (4U) on page 1-5.

WARNING!

Ground the relay to station ground using the case-grounding terminal at the back of the relay, for details see Figure 1.5: L-PRO Relay Rear View (4U) on page 1-5.

2.3 Time Sources

The L-PRO 4000 Line Protection relay supports the use of modulated or unmodulated IRIG-B time signals (external), primary/secondary SNTP network based time synchronization (external) and manually configurable system time based on a free-running, internal oscillator. The internal free-running oscillator is always present on the IED and, in the absence of any external time source, will become the default mode of time synchronization.

An externally applied IRIG-B time source will have the highest order of precedence, and will typically offer the highest available time accuracy, exceeding 1 µs after calibration, when derived from an external GPS satellite source. The L-PRO 4000 Line Protection relay will also process derived IRIG-B style signals generated from alternate time sources, using time quality information to differentiate. The ongoing presence of a valid IRIG-B time source is indicated by an LED on the front panel of the IED and is evident in data records.

An SNTP time source has a lower order of precedence from a valid IRIG-B source. SNTP operation (primary and secondary) requires network access and the selection and configuration of suitable SNTP network sources. The SNTP time may be configured for re-synchronization cycles ranging from 15 minutes to 36 hours, adjusting the IED system time to an accuracy within +/- 1 second. No visual indication is provided on the IED front panel regarding the status of the SNTP synchronization however this information is available in data records.

The IED comes equipped with an internal free-running oscillator used to generate a 1 PPS time signal in the absence of any alternate available time source. Use of this oscillator as the primary IED time source requires manual time configuration, with the general accuracy subject to user input parameters, and is recommended primarily for stand-alone, unsynchronized applications. The internal oscillator carries a lifetime accuracy (including temperature effects and aging) of +/-25 ppm.

2.4 Communicating with the Relay Intelligent Electronic Device (IED)

Connect to the relay to access its user interface and supervisory control and data acquisition (SCADA) services by:

- Front USB 2.0 interface (maintenance)
- 1 front and 2 rear Ethernet network links (user interface and SCADA)
- Direct serial link (user interface and SCADA)
- External or internal modem link (user interface only)

The relay has a front panel USB(Port 150) and 1 front Port 119 and 1 rear panel Ethernet port 119 and 1 rear panel Ethernet Port 120 and 2 rear serial Ports 122 and 123) to provide direct access to its user interface and SCADA services.

The relay’s user interface is accessed through the Relay Control Panel.

2.5 USB Link

The PC must be appropriately configured for USB communication.

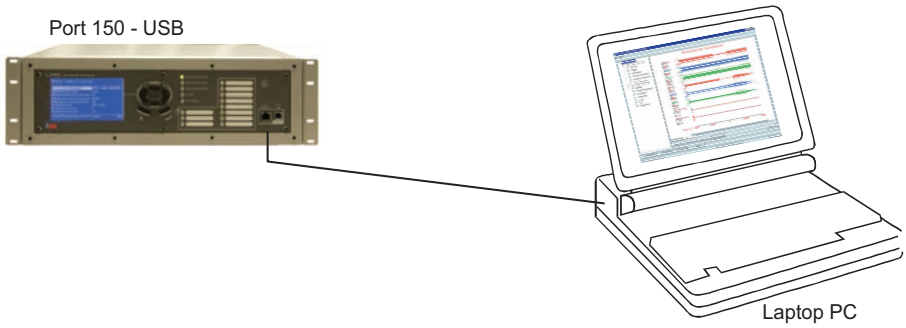


Figure 2.1: USB Link

USB Driver Installation

To create an USB link between the relay and the computer, first the USB driver for the ERLPhase 4000 series device needs to be installed, as follows:

Unzip the file (can be obtained from ERL website):

ERLPhase_USB_driver.zip

In this case we assume you unzipped to the desktop.

In Windows XP or Windows 7

Connect a USB port of the PC to Port 150 (USB front) of the LPRO-4000. The LPRO-4000 was already powered on.

In the window

"Welcome to the Found New Hardware Wizard"
"Can Windows connect to Windows Update to search for software?"

Check the option "No, not this time".

In the window

"This wizard helps you install software for:"
"ERLPhase 4000 Series Device"
"What do you want the wizard to do?"

Check the option "Install from a list or specific location (Advanced)".

In the window

"Please choose your search and installation options"
"Search for the best driver in these locations"

Uncheck the option “Search removable media (floppy, CD-ROM.)”.

Check the option “Include this location in the search”.

Browse for the following folder:

C:\WINDOWS\tiinst\TUSB3410

In the window

“Hardware Installation”
“The software you are installing for this hardware”
“ERLPhase 4000 Series Device”
“has not passed Windows Logo testing to verify its compatibility with Windows XP” or “Windows can’t verify the publisher”

Hit *Continue Anyway*.

In the window

“Completing the Found New Hardware Wizard”
“The wizard has finished installing the software for”

“ERLPhase 4000 Series Device”

Hit *Finish*.

To verify the installation was successful, and to which comm port is the ERL-Phase 4000 Series Device configured, do the following:

In Windows XP

Start > Control Panel->Performance and Maintenance->System >Hard-ware > Device Manager > Ports

or (if using Control Panel’s Classic View)

Start > Control Panel > System > Hardware >Device Manager >Ports

In Windows 7 ‘small icons’ view, go to

Start>Control Panel>Device Manager>Ports.

Look for the port number associated to this device.

“ERLPhase 4000 Series Device”
Look for a COM#, where “#” can be 1, 2, 3, etc. Leave the default settings for this port.

It is recommended to restart the PC after the USB driver installation.

The default baud rate for the relay USB Port 150 is 115200, however to double check it login to the relay display and go to:

Main Menu > System > Relay Comm Setup

2.6 Network Link

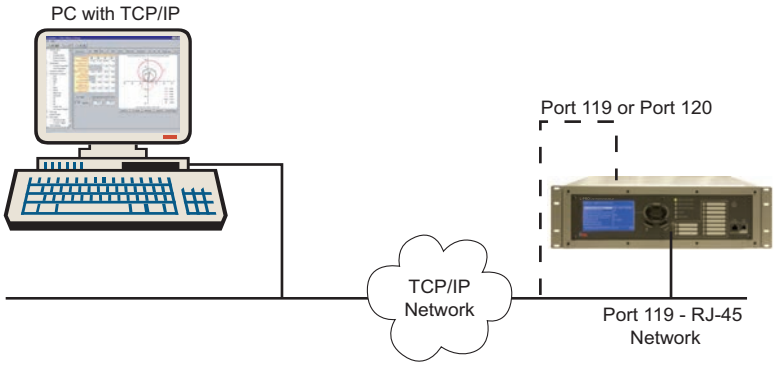


Figure 2.2: Network Link

Access both the relay's user interface and DNP3 SCADA services simultaneously with the Ethernet TCP/IP LAN link through the network ports Port 119 and Port 120. The rear Port 119 and 120 are either 100BASE-T copper interface with an RJ-45 connector or 100BASE-FX optical interface with an ST style connector. Each port is factory configurable as a copper or optical interface. The front Port 119 is 100BASE-T copper interface with an RJ-45 connector.

DNP3 SCADA services can also be accessed over the LAN, for details see "Communication Port Details" on page 2-15.

Connect to the Ethernet LAN using a Cat 5 cable with an RJ-45 connector or 100BASE-FX 1300 nm, multimode optical fiber with an ST style connector.

By default, the Port 119 is assigned with an IP address of 192.168.100.80 Port 120 is assigned with an IP address of 192.168.101.80. If this address is not suitable, it may be modified using the relay's Maintenance Menu. For details see "Using HyperTerminal to Access the Relay's Maintenance Menu" on page 2-9.

2.7 Direct Serial Link

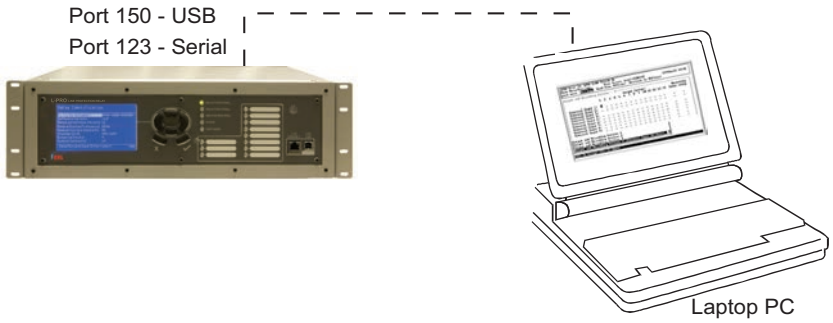


Figure 2.3: Direct Serial Link

To create a serial link between the relay and the computer, connect the computer's serial port and Port 123 on the relay's rear panel provided the port is not configured for modem use.

The serial ports are configured as EIR RS-232 Data Communications Equipment (DCE) devices with female DB9 connectors. This allows them to be connected directly to a PC serial port with standard straight-through male-to female serial cable, for pin-out details see "Communication Port Details" on page 2-15. Rear Port 122 is for SCADA and Port 123 can be used for direct serial access and external modem.

Ensure the relay port and the PC's port have the same baud rate and communications parameter, see "Maintenance Menu Commands" on page 2-11.

2.8 Modem Link

External

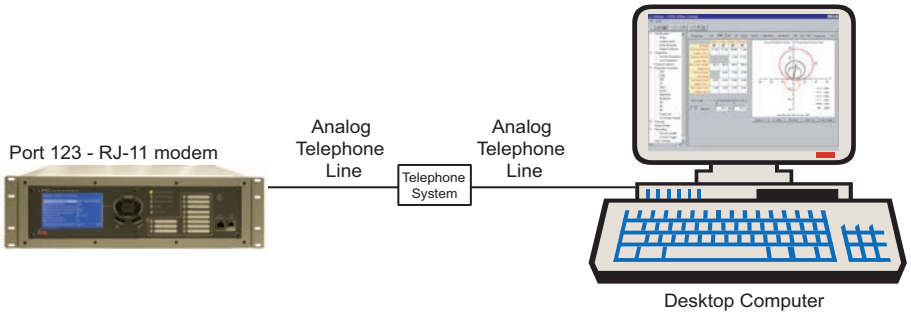


Figure 2.4: External Modem Link

Using an external modem, access the relay's user interface through a telephone link between the relay and the computer.

Connect the serial port on the external modem to the Port 123 on the relay's rear panel. Both devices are configured as RS-232 DCE devices with female connectors, so the cable between the relay and the modem requires a crossover and a gender change. Alternatively, use the ERLPhase modem port adapter provided with the relay to make Port 123 appear the same as a PC's serial port. A standard modem-to-PC serial cable can then be used to connect the modem and the relay. For pin-out details see "Communication Port Details" on page 2-15.

Connect the modem to an analog telephone line or switch using a standard RJ-11 connector.

Configure the relay's Port 123 to work with a modem. Log into the relay through Relay Control Panel, go to *Utilities>Communication* and select *port 123*. Set the *Baud Rate* as high as possible – most modems handle 57,600 bps. The *Initialize* setting allows the user to set the control codes sent to the modem at the start of each connection session. The factory defaults are: "M0S0=0&B1" for an external modem and "M0S0=0" for an internal modem.

Internal

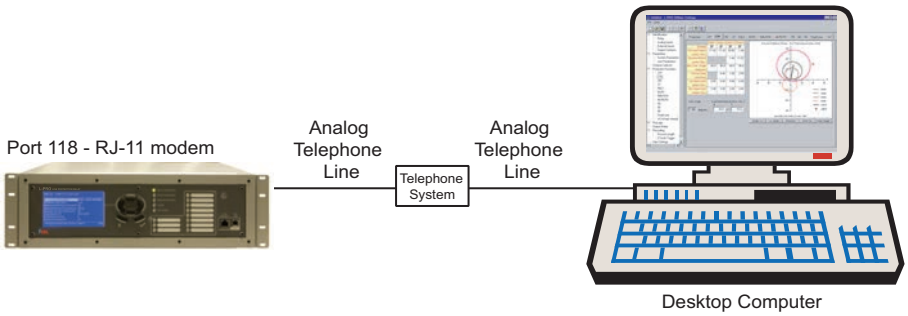


Figure 2.5: Internal Modem Link

Access the relay's user interface through a telephone link between the relay and the computer using an optional internal modem. If the modem has been installed, Port 118 on the rear panel is labelled "INTERNAL MODEM."

Connect the relay's Port 118 to an analog telephone line or switch using a standard RJ-11 connector.

When an internal modem is installed, the relay's Port 118 is used to interface to the modem internally. Appropriate Port 118 settings are configured at the factory when the internal modem is installed. The factory defaults are: "M0S0=0&B1" for an external modem and "M0S0=0" for an internal modem.

2.9 Using HyperTerminal to Access the Relay's Maintenance Menu

This section describes how to configure a standard Windows VT-100 terminal program on the PC for use with the relay.

The computer must be connected to the relay via the front USB port 150.

The relay is accessed using a standard VT-100 terminal style program on the computer, eliminating the need for specialized software. Any terminal program that fully supports VT-100 emulation and provides z-modem file transfer services can be used. HyperTerminal, which is included in Windows XP and is also available separately as HyperTerminal PE, is used here as an example.

Configure the terminal program as described in Table 2.1:Terminal Program Setup and link it to the appropriate serial port, modem or TCP/IP socket on the computer.

Table 2.1: Terminal Program Setup

Baud rate	Default fixed baud rate 115,200 N81 (no parity, 8 data bits, 1 stop bit).
Data bits	8
Parity	None
Stop bits	1
Flow control	Hardware or Software. Hardware flow control is recommended. The relay automatically supports both on all its serial ports.
Function, arrow and control keys	Terminal keys
Emulation	VT100
Font	Use a font that supports line drawing (e.g. Terminal or MS Line Draw). If the menu appears outlined in odd characters, the font selected is not supporting line drawing characters.

To configure HyperTerminal follow these instructions:

In Windows 7 open HyperTerminal PE; in Windows XP go to

Start > All Programs > Accessories > Communications > HyperTerminal

If "Default Telnet Program?" windows pops up,

Check "Don't ask me this question again"

Hit *No*.

First time use of HyperTerminal will ask for "Location Information".

Fill with appropriate information, e.g.:

"What country/region are you in now"
Choose "Canada"

"What area code (or city code) are you are in now?"
Enter "306"
"If you need to specify a carrier code, what is it?"
Enter "", i.e. leave blank
"If you dial a number to access an outside line, what is it?"
Enter "".
"The phone system at this location uses:"
Choose "Tone dialing".

Hit *OK*.

First time use of HyperTerminal will show "Phone and Modem Options".

Hit *Cancel*.

HyperTerminal will show initially "Connection Description".

Enter a name for the relay, e.g: "LPRO4000".

Hit *OK*.

In the window "Connect To"

"Connect using"

Choose "COM#", where "#" was obtained previously in Section 2.5 USB Link, after installing the USB driver.

Let's assume in this case it is COM3.

In the window "COM3 Properties" choose:

"115200"

"8"

"None"

"1"

"Hardware"

Hit *Apply* then hit *OK*

At this time the connection should already be established.

Hit *Enter* in the terminal window.

Login as **maintenance** in lower case.

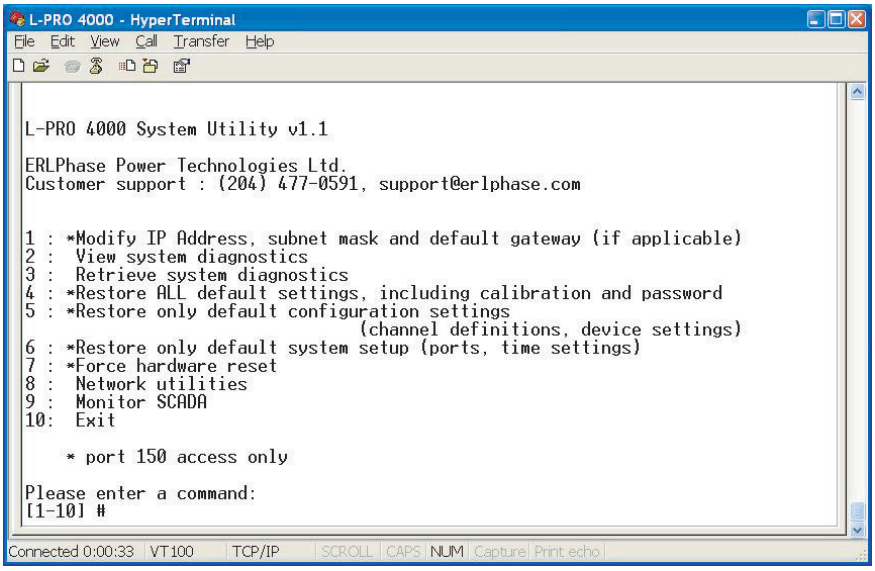

L-PRO 4000 - HyperTerminal
File Edit View Call Transfer Help
L-PRO 4000 System Utility v1.1
ERLPhase Power Technologies Ltd.
Customer support : (204) 477-0591, support@erlphase.com
1 : *Modify IP Address, subnet mask and default gateway (if applicable)
2 : View system diagnostics
3 : Retrieve system diagnostics
4 : *Restore ALL default settings, including calibration and password
5 : *Restore only default configuration settings
(channel definitions, device settings)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: Exit
* port 150 access only
Please enter a command:
[1-10] #
Connected 0:00:33 VT100 TCP/IP SCROLL CAPS NUM Capture Print echo

Figure 2.6: Maintenance Menu

Maintenance Menu Commands

Commands 1, 4, 5, 6 and 7 are Port 150 access only.

Table 2.2: Maintenance Menu Commands

Modify IP address	Modifies the LAN IP addresses, network mask, default gateway and IEC61850 network port assignment.
View system diagnostic	Displays the internal status log.
Retrieve system diagnostics	Automatically packages up the internal status log plus setting and setup information and downloads it in compressed form to the computer. This file can then be sent to our customer support to help diagnose a problem.
Restore settings (commands 4, 5 and 6)	Use these commands to force the system back to default values, if a problem is suspected due to the unit's settings, calibration and/or setup parameters.
Force hardware reset	Manually initiates a hardware reset. Note that the communication link is immediately lost and cannot be reestablished until the unit completes its start-up.
Network utilities	Enters network utilities sub-menu.
Monitor SCADA	Shows real time display of SCADA data.

Table 2.3: Network Utilities Menu Commands	
View protocol statistics	View IP, TCP and UDP statistics
View active socket states	View current states of active sockets
View routing tables	View routing tables
Ping	Check network connection to given point
Exit network utilities	Exit network utilities menu and return to Maintenance Menu Commands

2.10 Firmware Update

The relay has an update login that can be accessed by a connection through a VT100 terminal emulator (such as HyperTerminal). This login is available only from Port 150.

1. Use the terminal program to connect to Port 150.
2. Select *Enter*, the terminal responds with a login prompt.
3. Login as **update** in lower case.

The firmware update is used to update the relay's software with maintenance or enhancement releases. Please see the L-PRO Firmware Update Procedure documentation that comes with the firmware update for instructions on how to update the firmware on the relay.

2.11 Setting the Baud Rate

The baud rate is available on the LCD screen from the top level menu selecting *System* then *Relay Comm Setup*.

Direct Serial Link

For a direct serial connection, both the relay and the computer must be set to the same baud rate.

To change the baud rate of a relay serial port:

1. The user needs to log into the relay as **Change** (any port) or **Service** (USB port only) using RCP.
2. Then choose *Utilities>Communication* tab.

Modem Link

Unlike a direct serial link, the baud rates for a modem link do not have to be the same on the computer and on the relay. The modems automatically negotiate an optimal baud rate for their communication.

The baud rate set on the relay only affects the rate at which the relay communicates with the modem. Similarly, the baud rate set in HyperTerminal only affects the rate at which the computer communicates with its modem. Details on how to set these respective baud rates are described above, except that the user modifies the Port 123 baud rate on the relay and the properties of the modem in HyperTerminal.

2.12 Accessing the Relay's SCADA Services

The relay supports DNP3 (Level 2) and Modbus SCADA protocols as a standard feature on all ERLPhase relays. DNP3 is available through a direct serial link or the Ethernet LAN on top of either TCP or UDP protocols. The Modbus implementation supports both Remote Terminal Unit (RTU) binary or ASCII modes and is available through a direct serial link.

The relay's Port 122 is dedicated for use with Modbus or DNP3 serial protocols. Port 122 uses standard RS-232 signalling. An external RS-232<->RS-485 converter can also be used to connect to an RS-485 network.

For details on connecting to serial Port 122 see "Communicating with the Relay Intelligent Electronic Device (IED)" on page 2-2 and "Communication Port Details" on page 2-15.

The DNP3 protocol can also be run across the Ethernet LAN. Both DNP over TCP and DNP over UDP are supported. For details on connecting to the Ethernet LAN see "Network Link" on page 2-5.

Complete details on the Modbus and DNP3 protocol services can be found in the Appendices, for details see "Modbus RTU Communication Protocol" in Appendix E and "DNP3 Device Profile" in Appendix F

Protocol Selection

To select the desired SCADA protocol go to L-PRO 4000 Offliner SCADA communications section. Select the protocol and set the corresponding parameters.

Communication Parameters

Port 122's communication parameters are set in the L-PRO 4000 Offliner SCADA communications section Both the baud rate and the parity bit can be configured. The number of data bits and stop bits are determined automatically by the selected SCADA protocol. Modbus ASCII uses 7 data bits. Modbus RTU and DNP Serial use 8 data bits. All protocols use 1 stop bit except in the case where either Modbus protocol is used with no parity; this uses 2 stop bits, as defined in the Modbus standard.

Diagnostics

Protocol monitor utilities are available to assist in resolving SCADA communication difficulties such as incompatible baud rate or addressing. The utilities can be accessed through the Maintenance Menu Commands, see "Maintenance Menu Commands" on page 2-11

2.13 Communication Port Details

Table 2.4: Communication Port Details

Location	Port	Function
Front Panel	119	RJ-45 receptacle, 100BASE-T Ethernet interface. Default IP = 192.168.100.80 Used for user interface access or SCADA access through Ethernet LAN.
Front Panel	150	USB-B receptacle, High speed USB 2.0 interface Used for user interface access Default fixed baud rate 115,200 N81 (no parity, 8 data bits, 1 stop bit).
Rear Panel	118	RJ-11 receptacle, Internal modem interface. Default Baud rate 38,400 N81 (no parity, 8 data bits, 1 stop bit)
Rear Panel	119	Rear panel, RJ-45 receptacle or ST type optical receptacle (factory configured). 100BASE-T or 100BASE-FX (1300nm, multi-mode) Ethernet interface. Same subnet as front panel port 119. Used for user interface access or IEC61850/DNP SCADA access through Ethernet LAN.
Rear Panel	120	Rear panel, RJ-45 receptacle or ST type optical receptacle (factory configured). 100BASE-T or 100BASE-FX (1300 nm, multi-mode) Ethernet interface. Same subnet as front panel port 119. Used for user interface access or IEC61850/DNP SCADA access through Ethernet LAN.
Rear Panel	121	BNC receptacle, IRIG-B Interface. Modulated or un-modulated, 330 ohm impedance.
Rear Panel	122	RS-232 DCE female DB9. Used for SCADA communication. Default Setting: 19,200 baud O71 (odd parity, 7 data bits, 1 stop)
Rear Panel	123	RS-232 DCE female DB9. Used for: • User interface access through a direct serial connection. • Default Setting: 9600 baud N81 (no parity, 8 data bits, 1 stop bit). • User interface access through an external modem. The optional ERLPhase Modem Adapter converts this port to a Data Terminal Equipment (DTE) to simplify connection to an external modem.

Table 2.5: Signal connections to pins on Relay Port		
Signal Name	**Direction PC<-> Relay**	**Pin # on the Relay Port**
DCD	←	1
RxD	←	2
TxD	→	3
DTR	→	4
Common		5
DSR	←	6
RTS	→	7
CTS	←	8
No connection		9

Notes:
Relay is DCE, PC is DTE.
Pins 1 and 6 are tied together internal to the relay.

Table 2.6: Cable Pin Connections	
Male DB-9 Cable End for Relay Port	**Female DB-9 Cable End for Computer Port**
Pin # on Cable	Pin # on Cable
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

Table 2.7: Signal name connections to pins on Modem Adapter

Signal Name	Direction Modem <-> Relay	Pin # on the Modem Adapter
DCD	→	1
RxD	→	2
TxD	←	3
DTR	←	4
Common		5
DSR	→	6
RTS	←	7
CTS	→	8
No connection		9

Notes:
Relay (with modem adapter) is DTE, modem is DCE.
Pins 1 and 6 are tied together internal to the relay.

3 Using the IED (Getting Started)

3.1 Introduction

This section provides information on the start-up sequence and ways to interface with the relay. Descriptions of the Front Panel Display, Terminal Mode and Metering Data are provided.

3.2 Start-up Sequence

When the power supply is connected, the following initialization initializing sequence takes place:

Table 3.1: Initialization Sequence

TEST MODE — red LED on	when power applied
RELAY FUNCTIONAL — green LED on	within 5 seconds after power applied
TEST MODE — red LED off then on	within 10 seconds
Front Display — on	on within 20 seconds after power applied
TEST MODE — red LED off	within 20 seconds after power applied

When the Relay Functional LED comes on, it indicates that the DSP is actively protecting the system.

When the test mode LED goes off, the relay is capable of recording and communicating with the user.

3.3 Interfacing with the Relay

The following ways can be used to interface with the relay:

- Front panel display
- Terminal mode (for maintenance and firmware upgrade)
- Relay Control Panel

3.4 Front Panel Display

The front panel display of the IED allows the user to interact with the unit to obtain immediate system information. User interface is provided through a graphical LCD screen, LEDs and a push button keypad. The level of interaction and system access is controlled through a series of access level; VIEW, CHANGE and SERVICE, with each requiring a unique password allowing differing levels of accessibility. Additionally, the IED front panel provides an RJ-45 Ethernet port and a USB Type B port, used in general unit communications and controlled service access.

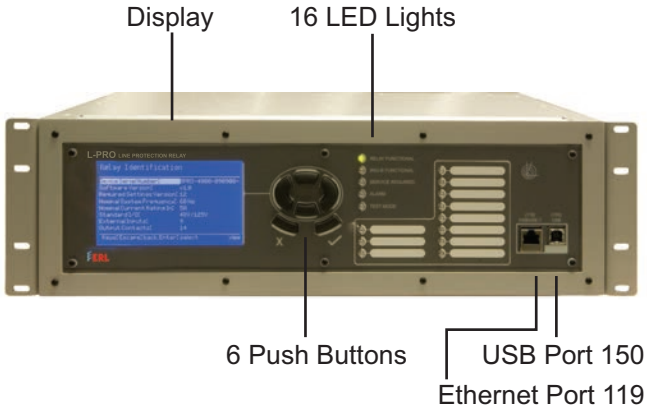


Figure 3.1: Front Panel Display

LED Lights

Table 3.2: Description of LED Lights	
Relay Functional	Indicates when the relay is functional. When the Relay Functional green LED goes on, the rear Relay Inoperative contact changes to an open and the protective functions become functional.
IRIG-B Functional	Indicates the presence of a valid IRIG-B time signal where the LED is on.
Service Required	Indicates the relay needs service. This LED can be the same state as the Relay Functional LED or can be of the opposite state depending on the nature of the problem. The following items bring up this LED: • DSP failure - protection difficulties within the relay. • Communication failure within the relay. • Internal relay problems.
Test Mode	Occurs when the relay output contacts are intentionally blocked. Possible reasons are: • Relay initialization on startup • User interface processor has reset and is being tested. The user cannot communicate with the relay through the ports until the front display becomes active and the TEST MODE LED goes out. Normally, the red Target LED remains off after this start-up unless the relay had unviewed target messages.

Table 3.2: Description of LED Lights	
Alarm	Occurs when an enabled relay function picks up. The red Alarm LED should be off if there are no inputs to the relay. If the Alarm LED is on, check the event log messages which are available through the menu system.
Target LED Number	**Description (Default values)**
1	Any device 21P trip operation (phase distance - 21P1, 21P2, 21P3, 21P4)
2	Any device 21N trip operation (ground distance - 21N1, 21N2, 21N3, 21N4)
3	Any device 50 or 51 trip operation (phase overcurrent - 50 or 51, neutral overcurrent - 50N or 51N, negative sequence overcurrent 46-50 or 46-51)
4	Any device 50BF trip operation (breaker failure - 50BF Main-1, 50BF Main-2, 50BF Aux-1, 50BF Aux-2)
5	Any device 81 trip operation (over/under-frequency - 81-1, 81-2, 81-3, 81-4)
6	Switch-On-To-Fault trip operation
7	Communication Scheme trip operation
8	Device 68 trip operation Power Swing trip
9	ProLogic 1 - 8
10	ProLogic 9 - 16
11	ProLogic 17 - 24

Phase segregated Trip LED Indications (user configurable) are available for the following functions

- Distance, Carrier Trip
- Backup Overcurrent
- Overvoltage & undervoltage
- CB Fail Protection
- Back up earth fault
- SOTF Trip

Target LED assignments are the default values but are configurable by the user through the Offliner settings (output matrix configuration).

Push Buttons

Table 3.3: Identification of Push Buttons	
Up, Down, Right, Left, Enter, Escape	Used to navigate the front panel screens.

Display

The LCD screen of the L-PRO 4000 relay provides information to the user in the form of data, messages and visual feedback for user interaction. A series of access controlled menu options are available through the front panel LCD and Push Button keypad provided on the unit, allowing unit level access to many of the same features available through the supporting ERLPhase relay software tools. In all cases, a password is required to obtain more than the basic IED information.

The basic menu structure for navigation of the LCD screen is given below:

The LCD screen displays the following metering parameters.

- Phase wise voltage magnitude & angle
- Phase wise current magnitude & angle
- 3-phase real power
- 3-phase reactive power
- Frequency
- 3-phase apparent power
- Power factor
- All sequence voltages
- All sequence currents
- Single-phase real power
- Single-phase reactive power
- Single-phase Apparent power
- Single-phase power factor

The metering display in LCD screen has a resolution of three decimals for both measured and calculated analog values.

Table 3.4: Navigation of the LCD Screen		
Main Screen		
	View / Change / Service : Choice Menu	
	Enter Password	
	Main Menu	(V)

Table 3.4: Navigation of the LCD Screen

	System		(V)
		Relay Identification	(V)
		Relay Comm Setup	(V)
	Settings		[factory enabled] (C, S)
		System Parameters	
		Record Length	
		Setting Group 1	
		Setting Group 2	
		Setting Group 3	
		Setting Group 4	
		Setting Group 5	
		Setting Group 6	
		Setting Group 7	
		Setting Group 8	
	Metering		(V)
		Analog	(V)
			Analog Inputs (V)
			Line Quantities (V)
		External Inputs	(V)
		Output Contacts	(V)
		Logic	(V)
			Logic Protections 1 (V)
			Logic Protections 2 (V)
			ProLogic (V)
			Group Logics (V)
			Virtual Inputs (V)
	Records		(V)
		View Record List	(V)
		Fault Recording	(C,S)
		Swing Recording	(C,S)
		Event Recording	(C,S)
	Fault Log		
		Fault List	
	Event Log		(V)

Table 3.4: Navigation of the LCD Screen			
	Event List		
	Utilities		(V)
	Setup		(V)
		Timeouts	(V)
		Time Settings	(V)
		Set Manual Time	(V)
		Set DST Time	(V)
		External Inputs	(V)
	Maintenance		(V)
		Output Contacts Control	(S)
		Virtual Inputs Control	(C,S)
		Setting Groups Control	(C,S)
		Erase	(C,S)
		Erase Records	(C,S)
		Erase Event Logs	(C,S)
	Network		(V)
		Network Protocol Stats	(V)
		Active Sockets	(V)
		Routing Tables	(V)
		Ping	(V)
	Logout		(V)

Where the access levels required to access each are indicated by:

V: view

C: change

S: service

To login into the LCD menu structure, follow these steps:

Figure 3.2: Main Screen

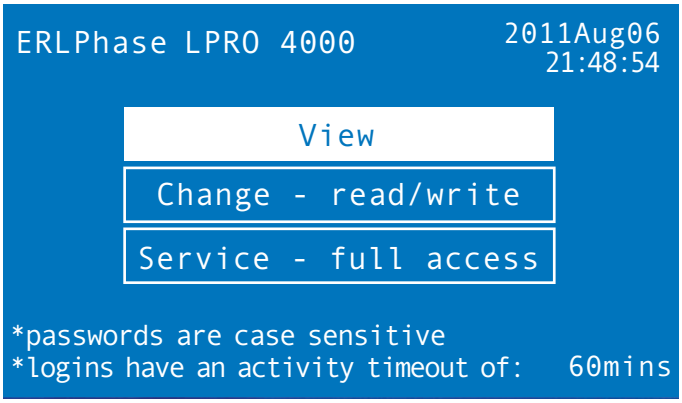


Figure 3.3: View / Change / Service: Choice Menu

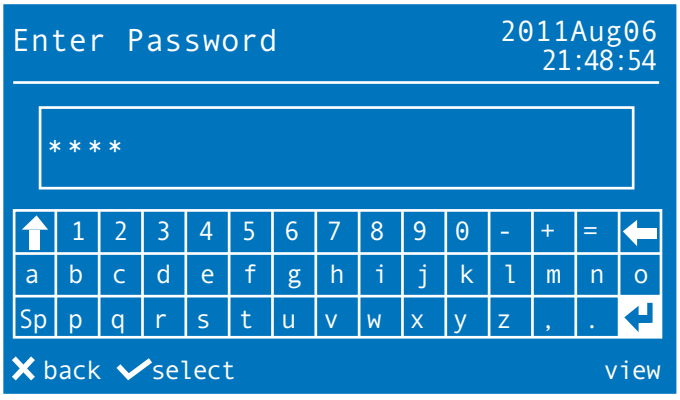


Figure 3.4: Enter Password

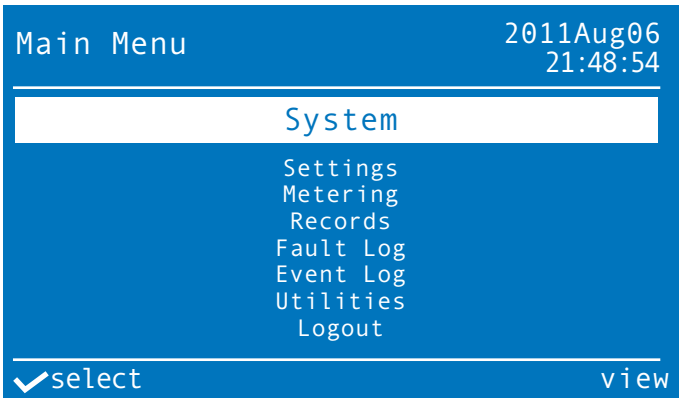


Figure 3.5: Main Menu

In the Main Screen, hit *Enter*.

In the View / Change / Service: Choose Menu screen, choose desired access level, hit *Enter*.

In the Enter Password screen, enter appropriate password, hit *Enter* on the return character (right bottom one)

The Main Menu screen should appear.

Note: The default passwords are (remove quotation marks)

View Access “view”

Change Access “change”

Service Access “service”

3.5 Terminal Mode

The terminal mode is used to access the relay for maintenance functions see “Using HyperTerminal to Access the Relay’s Maintenance Menu” on page 2-9 and “Firmware Update” on page 2-12.

3.6 Relay Control Panel

RCP is used for all user interface. A short description of the RCP configuration to connect to a relay is given here. Please refer to the Relay Control Panel User Manual for details.

The RCP displays the following metering parameters

- 3-phase apparent power
- Power factor
- All sequence voltages
- All sequence currents

- Single-phase real power
- Single-phase reactive power
- Single-phase Apparent power
- Single-phase power factor

The metering display in RCP has a resolution of three decimals for both measured and calculated analog values.

Follow this sequence to configure RCP for USB link to the relay.

1. Execute.
   Relay Control Panel.exe
2. Execute.
   L-PRO 4000 Offliner.exe
3. Install Null Modem Driver.
   Please refer to the Relay Control Panel User Manual for details.
4. Run Relay Control Panel.
   Go to:
   Start > All Programs > ERLPhase > Relay Control Panel > Relay Control Panel
   First time RCP is run.
   Hit *Add New*.
   "Add New Relay"
   Choose Communication > Direct Serial Link.
   Hit *Get Information From Relay.*
   Then RCP will communicate with the LPRO-4000 and retrieve information to fill required fields.
   When this is done, hit *Save Relay*.
   If the window "Relay already exists..." pops up, you may need to rename the relay changing the "Relay Name" in the "Relay Definition" category, before saving.
   After first time, in "Select Relay", choose relay and hit *Connect*.
   In "Relay Password Prompt"
   Choose desired access level, enter appropriate password
   Note: Default passwords are listed below (remove the quotation marks)
   View Access "view"
   Change Access "change"
   Service Access "service"
   The basic structure of the Relay Control Panel information, including basic actions available, is given below:

Table 3.5: Relay Control Panel Structure

			View	Change	Service
Relay Control Panel					
	Records			Trigger Fault	Trigger Fault
				Trigger Swing	Trigger Swing
				Trigger Event	Trigger Event
	Faults			Erase	Erase
	Events			Erase	Erase
	Metering				
		Analog			
		Line			
		External			
		Logic 1			
		Logic 2			
		ProLogic			
		Outputs			
		Group Logic			
		Virtual			
	Utilities				
		Unit Identification			
		Communication			
		Time			
		Analog Input Calibration	N/A	N/A	
		External Input			
		Virtual Inputs	N/A	Latch/Pulse	Latch/Pulse
		Toggle Outputs	N/A	N/A	Close/Open
		Settings Group		Save	Save
		Passwords	N/A	N/A	
	Configuration				

Table 3.5: Relay Control Panel Structure				
	Present Settings	(Get From Relay)		
	Saved Settings		(Load to Relay)	(Load to Relay)

Notice that some options are not available (N/A) depending on the access level.

4 Protection Functions and Specifications

4.1 Protection and Recording Functions

Introduction

This section describes the equations and algorithms of the relay protection functions. All functions with time delay provide an alarm output when their pickup level is exceeded.

The following functions are exceptions: 27 Auxiliary, 27 Main, 59 Auxiliary, 59 Main, 25/27/59 Sync Check, 50LS Main, 50LS Auxiliary, 50BF Main, 50BF Auxiliary, 81 Frequency and ProLogic elements.

A complete list of the settings and their range values can be found in "IED Settings and Ranges" in Appendix B.

21P Phase/21N Ground Distance

The relay 21P contains 5 zones of phase distance elements; all 5 zones of 21P can be set to either Mho or Quadrilateral type. Note that only one type can be used at a time. The 21P can contain a mixture of Mho and Quadrilateral shapes, for example the 21P1 and 21P2 can be set to a Mho characteristic and the 21P3, 21P4 and 21P5 could be set to a Quadrilateral characteristic.

The relay 21N contains 5 zones of ground distance elements; all 5 zones of 21N can be set to either Mho or Quadrilateral type. Note that only one type can be used at a time. The 21N can contain a mixture of Mho and Quadrilateral shapes, for example the 21N1 and 21N2 can be set to a Mho characteristic and the 21N3, 21N4 and 21N5 could be set to a Quadrilateral characteristic.

The Quadrilateral shape is parallel to the positive sequence line angle setting. The user-defined Mho Characteristic Angle is not selectable when a Quadrilateral characteristic for that particular zone is defined. All other settings are selectable and user-definable. Top blinder of quadrilateral shape can be adjusted using *Tilt Angle* setting as shown in Figure 4.4: Mho Characteristic Shapes on page 4-4.

Zones 3, 4 and 5 reach can be set in either forward direction or reverse direction or offset as required. All the distance functions are set in secondary ohms. The available range of impedance settings is based on the nominal current specified when the relay was ordered. The impedance reach ranges are given in Figure 4.1: Tilt Angle on page 4-2.

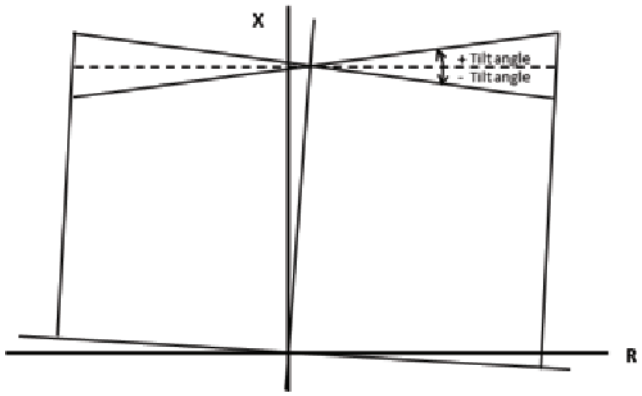


Figure 4.1: Tilt Angle

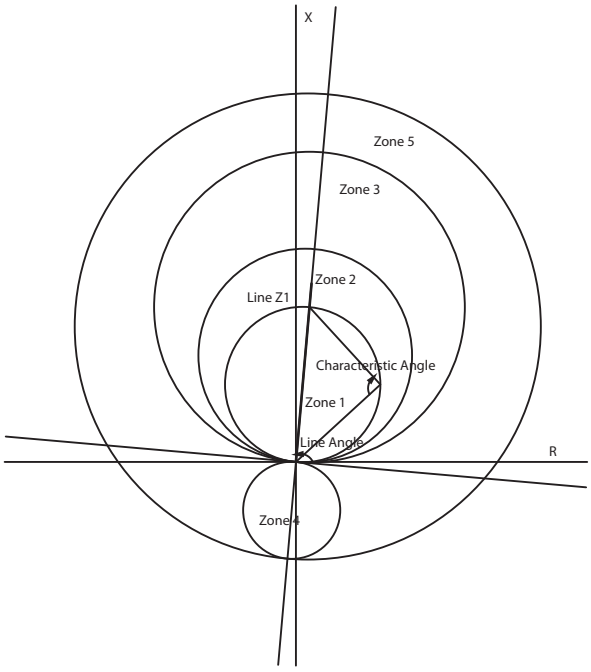


Figure 4.2: Phase and Ground distance protection Mho relay characteristic

The shape of the phase and ground distance relays is adjustable. For the circular Mho characteristic shape, the characteristic angle is 90 degrees. Determine this angle by drawing 2 lines from any point on the impedance locus to the diameter of the characteristic. Produce a tomato-shaped characteristic by selecting an angle less than 90 degrees or a lens-shaped characteristic with angles greater than 90 degrees.

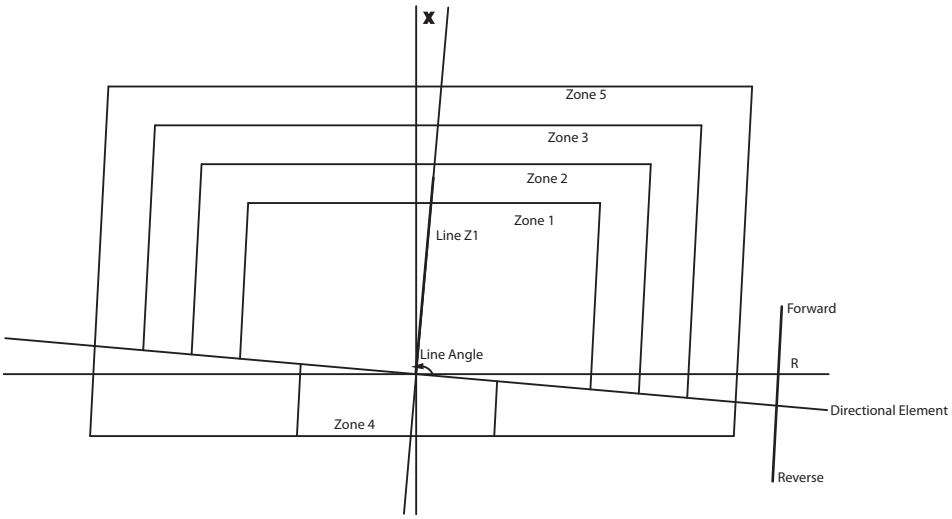


Figure 4.3: Phase and Ground distance protection Quadrilateral Characteristics

The shape of the Mho characteristic means that significant extensions are made to the relay characteristics in the R region of the R-X plane for ground faults. Restrict the reach in the R region for the phase distance relays where load encroachment is an issue. The shaped Mho characteristic provides the best fit for the application keeping the number of relay settings at a minimum and provides the benefits associated with the Mho characteristic.

The Mho characteristic used by the relay is developed by the classical approach using the measurement of the angle between 2 vectors.

These vectors are defined as:

$$A = I \times Z_{set} - V \quad (1)$$

$$B = V_{ref} \quad (2)$$

$$I_{phase} + K_o \times 3I_0 \quad (3)$$

where

V is the actual line voltage for ground distance relays or the actual line to line voltage for the phase distance relay.

I is defined as above for ground distance relays or the line to line current for phase distance relays.

Z_{set} is the setting reach and V_{ref} is a positive sequence memory voltage stored within the relay.

V_{ref} is the polarizing quantity for the Mho elements, and is more completely described in “Relay Method of Memory Polarization” on page 4-7.

To make the reach of the ground distance relay relate to the line positive sequence impedance the classical K_o factor is used.

This factor is defined as

$$K_0 = \frac{Z_0 - Z_1}{3Z_1} \quad (4)$$

The relay includes a directional element to supervise the phase (21P) and ground (21N) Mho elements, for all five Zones (21P1 to 21P5 and 21N1 to 21N5). The directional element improves security of the Mho elements for reverse faults such as: bus faults, phase-phase faults during high load conditions. The directional element does not supervise Zone 3, Zone 4 and Zone 5 elements if these zones are set as offset characteristic. The directional element is described in “Directional Element” on page 4-10.

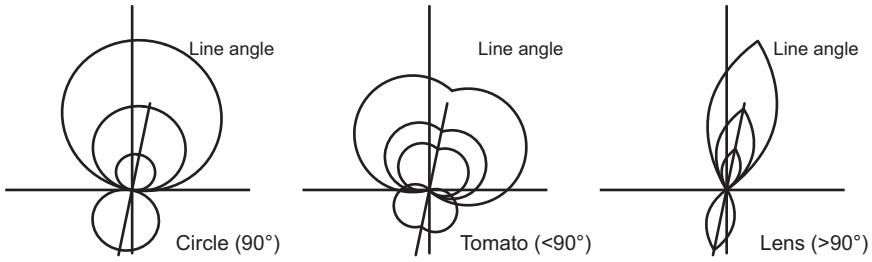


Figure 4.4: Mho Characteristic Shapes

Load Encroachment (LE)

The load impedance may enter into the protection zones permanently or temporarily due to system condition. This is observed in very long lines or heavily loaded medium lines will have issue. This is a normal load conditions and it is not an abnormal/fault conditions. Therefore, the relay should not initiate any trip command during this condition. The relay should identify properly whether the impedance entered into the protection zone is normal load condition or fault condition.

This is distinguished by monitoring all phase-to-phase impedance values (i.e. Zab, Zbc & Zca).If all the three phase impedances enter into the protection zones with the limited load angle area, it is declared as a loading condition and 21P function is blocked. If only one of the phase-to-phase impedance enters into the protection zones with the limited load angle area then this can be declared as fault condition.

Generally, the three phase fault will not have any additional resistance component other than the conductor resistance. Therefore, three phase fault will always have the fault angle as close to line angle only and it will not enter into the loading area.

Figure 4.5: Load Encroachment (LE) Logic on page 4-5 shows how the LE function works. Phase-to-phase current monitoring has been added to the logic to ensure stable operation.

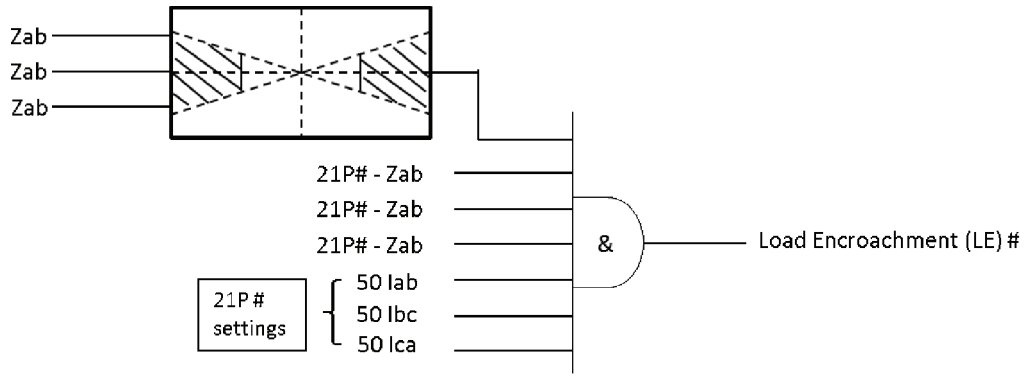


Figure 4.5: Load Encroachment (LE) Logic

Table 4.1: 21P Phase Distance Element Settings

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	
	Enable/ Disable	Enable/ Disable	Enable/ Disable	Enable/ Disable	Enable/ Disable	
Characteristic Type	Mho / Quadrilateral	Mho / Quadrilateral	Mho / Quadrilateral	Mho / Quadrilateral	Mho / Quadrilateral	
Forward Impedance Reach (Ohms secondary)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	Both
Forward Reactance Reach (Ohms secondary)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	Quadrilateral
Reverse Impedance Reach (Ohms secondary)			0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	Both
Reverse Reactance Reach (Ohms secondary)			0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	Quadrilateral
Left Reach (R1) (Ohms secondary)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	Quadrilateral

Table 4.1: 21P Phase Distance Element Settings						
Right Reach (R2) (Ohms secondary)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	Quadrilateral
Mho Characteristic Angle (degrees)	70.0 to 140.0	70.0 to 140.0	70.0 to 140.0	70.0 to 140.0	70.0 to 140.0	Mho
Pickup Delay (seconds)	0.00 to 99.00	0.00 to 99.00	0.00 to 99.00	0.00 to 99.00	0.00 to 99.00	Both
Id Supervision (A secondary)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	Both
Line Angle (degrees)	5.0 to 89.0 Setting is made in Line Parameters (Positive Sequence Angle)					
Load Impedance (Ohms)						
R (Ohms secondary)	-150.0 to 150.0					Both
X (Ohms secondary)	-150.0 to 150.0					Both
Load Encroachment	Enable/Disable					Both
LHS						
Impedance (Ohms secondary)	0.01 to 66.0 (5 A) 0.05 to 330.0 (1 A)					Both
Upper angle (degrees)	90.1 to 179.9					Both
Lower angle (degrees)	180.1 to 269.9					Both
RHS						
Impedance (Ohms secondary)	0.01 to 66.0 (5 A) 0.05 to 330.0 (1 A)					Both
Upper angle (degrees)	0.1 to 89.9					Both
Lower angle (degrees)	-0.1 to -89.9					Both

Table 4.2: 21N Ground Distance Element Settings						
	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	
	Enable/ Disable	Enable/ Disable	Enable/ Disable	Enable/ Disable	Enable/ Disable	
Characteristic Type	Mho / Quadrilateral	Mho / Quadrilateral	Mho / Quadrilateral	Mho / Quadrilateral	Mho / Quadrilateral	
Forward Impedance Reach (Ohms secondary)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	Both

Table 4.2: 21N Ground Distance Element Settings						
Forward Reactance Reach (Ohms secondary)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	Quadrilateral
Reverse Impedance Reach (Ohms secondary)			0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	Both
Reverse Reactance Reach (Ohms secondary)			0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	0.00 to 66.00 (5A) 0.00 to 330.00 (1A)	Quadrilateral
Left Reach (R1) (Ohms secondary)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	Quadrilateral
Right Reach (R2) (Ohms secondary)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	0.05 to 66.00 (5A) 0.25 to 330.00 (1A)	Quadrilateral
Mho Characteristic Angle (degrees)	70.0 to 140.0	70.0 to 140.0	70.0 to 140.0	70.0 to 140.0	70.0 to 140.0	Mho
Pickup Delay (seconds)	0.00 to 99.00	0.00 to 99.00	0.00 to 99.00	0.00 to 99.00	0.00 to 99.00	Both
Id Supervision (A secondary)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	Both
3I0 Supervision (A secondary)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	0.2 to 50.0 (5A) 0.04 to 10.00 (1A)	Both
Line Angle (degrees)	5.0 to 89.0 Setting is made in Line Parameters (Positive Sequence Angle)					
Load Impedance (Ohms)						
R (Ohms secondary)	-150.0 to 150.0					Both
X (Ohms secondary)	-150.0 to 150.0					Both

Relay Method of Memory Polarization

The 21P and 21N Mho/Quad elements use positive-sequence voltage, derived from a memory voltage, as the polarizing quantity. No user settings are required for the memory polarization functionality. Sufficient positive-sequence voltage should be available during all fault events. However, during certain fault events, especially 3-phase bolted faults near the line VT location, the positive-sequence voltage may be insufficient for correct operation. To ensure adequate positive-sequence voltage exists for all fault conditions, the relay uses a ring filter, implemented in software, to provide memory voltage as the source for the positive-sequence voltage. This memory voltage lasts for approximately 150 cycles, even if all voltage inputs from the line VTs go to zero. A practi-

cal effect of using a memorized voltage is to expand the Mho characteristic by the magnitude of the source impedance see “Effect of using Memorized Voltage on a 3-phase forward fault condition” on page 4-8. This expansion of the characteristic ensures correct operation for zero voltage faults at the relay location, and for forward capacitive faults.

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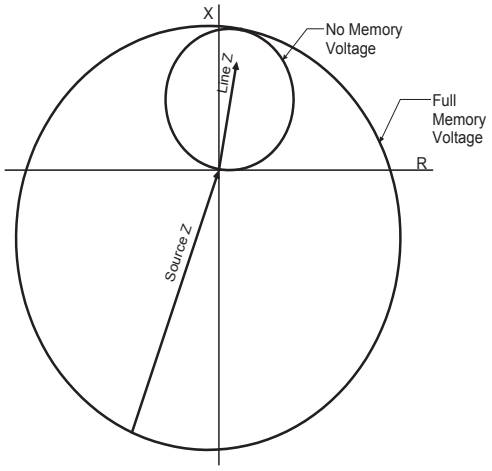

Figure 4.6: Effect of using Memorized Voltage on a 3-phase forward fault condition

Ring Filter

The voltage memory in the relay uses a ring filter implemented in software. The ring filter is a high-Q bandpass filter, with the frequency response centered on the nominal system frequency. The effect of the ring filter is to retain some voltage information for approximately 150 cycles, even if the measured system voltage is severely depressed by a fault.

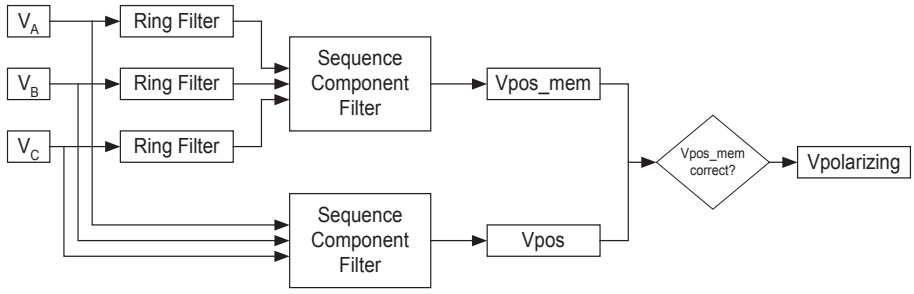

Figure 4.7: Polarizing Voltage

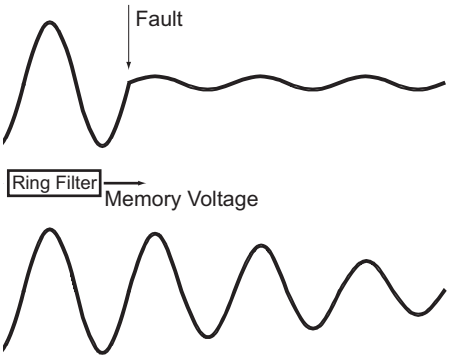

Figure 4.8: Effect of the Ring Filter

The ring filter is designed to adjust the center of the frequency response to account for small variations of the power system frequency. When the measured voltage drops below 0.5 V_{sec}, the ring filter explicitly uses the nominal system frequency as the center point of the bandpass filter. During this condition, or when the system frequency varies widely or rapidly, as during out-of-step conditions, the ring filter could provide an incorrect output. During these conditions, the 21P and 21N Mho/Quad elements use the positive-sequence voltage derived from the system voltage directly from the line VTs until the voltage output of the ring filter is correct. If the measured positive sequence voltage is below 1 Vsec, then the Mho/Quad elements use the positive sequence voltage derived from the memory voltage

Directional Element

The relay includes a directional element that directly supervises the Zone 1 to Zone 5 phase and ground distance elements. The directional element considers negative-sequence impedance, zero-sequence impedance, or positive-sequence impedance, depending on relay settings and system conditions at the time of the fault. The element declares a forward fault when the impedance determined by the directional element is within 90° of the line impedance.

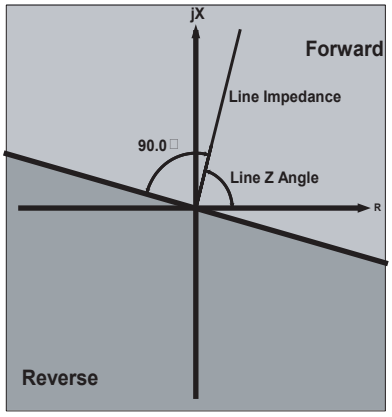

Figure 4.9: Fault Direction

The directional element in the relay is always enabled. The directional element actually consists of 3 separate internal elements: a negative-sequence element, a zero-sequence element, and a positive-sequence element. The negative-sequence and zero-sequence elements use directly measured currents and voltages. The positive-sequence element uses directly measured current, and a memory voltage from the ring filter. The sensitivity for the negative- and zero-sequence elements may be set by the user, to correctly account for load conditions and system configuration. Both of these elements may be disabled as well. The positive-sequence element is always active.

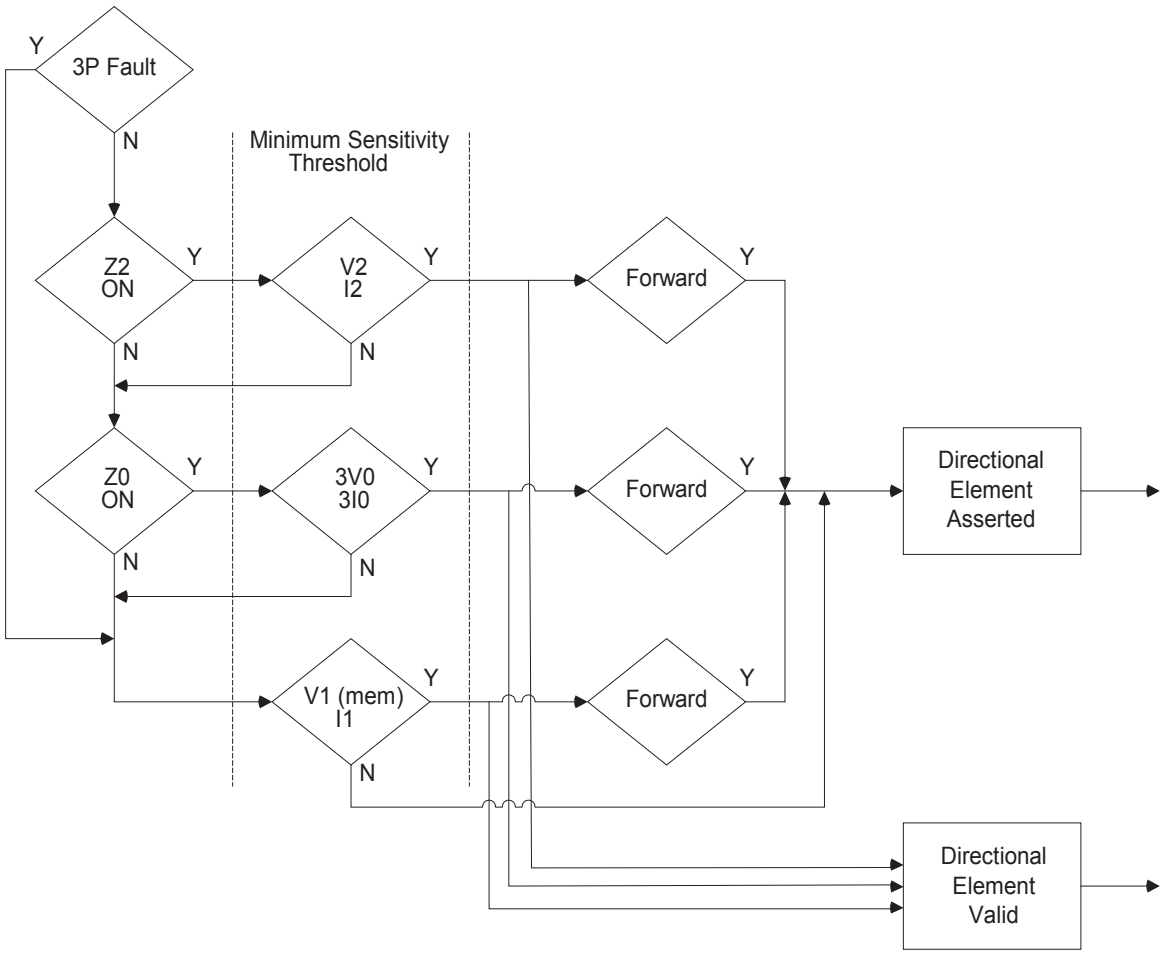

Figure 4.10: Directional Element Logic

For 3-phase faults, the directional element will only use the positive-sequence element. For all other faults, the directional element will consider, in order, the negative-sequence calculation, the zero-sequence calculation, and the positive-sequence calculation. The directional element will only move from one calculation to the next calculation if insufficient sequence voltages and currents exist to make a valid calculation.

The negative-sequence calculation determines the angle between the measured negative-sequence impedance, and the positive-sequence line impedance angle entered in settings. To perform this calculation, the default minimum amount of negative-sequence voltage required is 0.5 V secondary, and the default minimum amount of negative-sequence current required is 0.2 A secondary.

The zero-sequence calculation determines the angle between the measured zero-sequence impedance the zero-sequence line impedance angle entered in settings. To perform this calculation, the default minimum amount of zero-sequence voltage (3_{V0}) required is 1.0 V secondary, and the default minimum amount of zero-sequence current (3_{I0}) required is 0.2 A secondary.

The positive-sequence calculation determines the angle between the measured positive-sequence impedance (based on measured current, and the memory voltage output of the ring filter) and the positive-sequence line impedance angle entered in settings. To perform the positive-sequence impedance calculation, the directly measured positive-sequence current must exceed 0.2 A secondary, and the memorized positive-sequence voltage must exceed 2 V secondary.

There may be some rare circumstances where there may not be sufficient voltage or current, using the negative, zero, and positive sequence components, for the directional element to make a valid directional decision. The most likely circumstance where this may occur is a 3-phase bolted fault near the line VTs, that is not cleared in an appropriate amount of time. It takes approximately 30 cycles, after the measured 3-phase system voltage drops to 0, for the ring filter voltage to decay such that the Vpos_mem is less than 2 V secondary. For this circumstance, or for any other fault case where there are insufficient sequence component quantities for any of the directional calculations to operate, the direction is set to “forward”. Setting the reverse reach to zero sets the direction control to forward and setting the forward reach to zero sets the direction control to reverse. Setting both forward and reverse reaches non-zero sets the directional element to non-directional.

Directional Element Outputs

The output of the directional element asserts when the direction is determined to be “forward”. This output is used internally by protection functions directly supervised by the element, and is also available as the “Directional Element” indication in ProLogic equations. The directional element also provides the “Directional Valid” output for use in ProLogic equations. This output asserts when any one of the active sequence impedance calculations has sufficient input quantities to make a valid direction determination, regardless of the actual direction. The “Directional Valid” output will always be asserted, except in the rare case where system voltage has gone to 0 for more than 30 cycles, as previously described. The 2 outputs can be combined in a ProLogic equation to e a secure reverse directional output from the relay, for example.

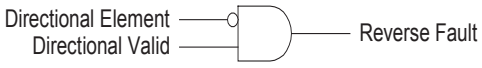

Figure 4.11: Directional Element

Directional Element Settings

The default setting of the directional element in the relay should be correct for most applications. The default settings enable both the negative-sequence and zero-sequence calculations, with the minimum sensitivities as described. There are some applications where it may be advisable to change the sensitivity thresholds for the negative-sequence or zero-sequence calculations, or it may be desirable to disable one or both of these elements.

Selecting “Directional Element Override Enabled” allows user settings for the negative-sequence and zero-sequence directional elements.

The settings for the negative-sequence voltage sensitivity and negative-sequence current sensitivity should be normally higher than the maximum negative sequence quantities generated by unbalanced load. These settings should also be low enough to maintain sensitivity for the minimum unbalanced fault, in terms of negative sequence quantities.

The zero-sequence directional element can be used in many applications. However, where strong mutual coupling between parallel lines exist, the zero-sequence calculation must be disabled to prevent an incorrect directional determination. The sensitivity settings should be low enough to permit operation during the lowest expected ground fault in terms of zero-sequence quantities expected during a fault, and high enough to allow for normal load imbalance.

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Table 4.3: Directional Element Settings	
Override Enabled	Enable/Disable
Negative-Sequence	Enable/Disable
V2 Sensitivity Level (V secondary)	0.5 to 5.0
I2 Sensitivity Level (A secondary)	0.1 to 1.0 (5 A) 0.02 to 0.20 (1 A)
Zero Sequence	Enable/Disable
3V0 Sensitivity Level (V secondary)	1.0 to 10.0
3I0 Sensitivity Level (A secondary)	0.2 to 2.0 (5 A) 0.04 to 0.40 (1 A)

21P and 21N Phase Selector

The phase selector algorithm for the relay ensures that:

- 21N only trips on single-phase-to-ground fault, so as to prevent 21N from false tripping for phase-to-phase-to-ground faults with arc resistance
- Supervise 21P for low Source Impedance Ratio (SIR) ratios and single-phase-to-ground faults at 20% of line reach or below.

Algorithm Details

The phase selector uses a combination of positive, negative and zero sequence current phasors to correctly determine the faulty phase. No user settings are required for the phase selector functionality. An OR function with angle checks between I_1 and I_2 as well as the angle between I_2 and I_0. The OR function allows the algorithm to adapt to various fault conditions and provide the correct fault type. When energizing a line with a T-tapped load, the user may have system conditions where no pre-trigger load current is available. Using positive and negative sequence currents alone may cause an incorrect fault determination if the load current is significantly large enough to affect the total positive sequence current, which includes both load and fault current. Our algorithm overcomes this problem.

Angle Relationship of Positive and Negative Sequence Currents

The angle comparison scheme is used to determine the faulty phase and the fault type. If the load current is subtracted from the total current (i.e. only fault current is left for angle comparison), the positive sequence (I_1) and negative sequence (I_2) current phase angle relations are listed in the following table:

Table 4.4: Angular difference between positive and negative sequence currents for various faults

	AG Fault	BG Fault	CG Fault	BCG Fault	ABG Fault	CAG Fault
Angle Diff. between I_{1A} and I_{2A} (AngleDiff_A)	0	120	120	180	60	60
Angle Diff. between I_{1B} and I_{2B} (AngleDiff_B)	120	0	120	60	60	180
Angle Diff. between I_{1C} and I_{2C} (AngleDiff_C)	120	120	0	60	180	60

Phase Selector Criteria for I1 and I2

The following criteria is used to determine the fault type and phase:

AG Fault: AngleDiff_A<45.0 and AngleDiff_B >90.0 and AngleDiff_C >90.0

BG Fault: AngleDiff_B<45.0 and AngleDiff_C >90.0 and AngleDiff_A >90.0

CG Fault: AngleDiff_C<45.0 and AngleDiff_A >90.0 and AngleDiff_B >90.0

In the above criteria only one can become true at a time. They are used to supervise 21N_A, 21N_B, 21N_C respectively.

Angle Relationship of Negative and Zero Sequence Currents

The angle comparison scheme is used to determine the faulty phase and the fault type. The negative sequence (I_2) and zero sequence (I_0) current phase angle relations are listed in the following table:

Table 4.5: Angular difference between negative and zero sequence currents for various faults

	AG Fault	BG Fault	CG Fault	BCG Fault	ABG Fault	CAG Fault
Angle Diff. between I_{2A} and I_0 (AngleDiff_I2_I0_A)	0	120	120	0	120	120
Angle Diff. between I_{2B} and I_0 (AngleDiff_I2_I0_B)	120	0	120	120	120	0
Angle Diff. between I_{2C} and I_0 (AngleDiff_I2_I0_C)	120	120	0	120	0	120

Phase Selector Criteria for I_2 and I_0

The following criteria is used to determine the fault type and phase:

AG Fault: AngleDiff_I2_I0_A<25.0 degrees

BG Fault: AngleDiff_I2_I0_B<25.0 degrees

CG Fault: AngleDiff_I2_I0_C<25.0 degrees

Though AG type of fault will be declared for a BCG fault by the above angle criteria between I_2 and I_0, the characteristic of AG impedance prevents AG from tripping because the phase selector is used for supervision only, i.e. the phase selector is not a tripping device.

Device 21P Supervision

A 21P supervision logic is formed based on the above Phase Selector Criteria. The phase-to-phase distance element is only allowed to operate if the faulted phase is not involved with the element:

21P_AB Supervision = Not AG Fault and Not BG Fault

21P_BC Supervision = Not BG Fault and Not CG Fault

21P_CA Supervision = Not CG Fault and Not AG Fault

The Start of the Phase Selector

The phase selector starts only when a fault occurs. The start definition is: if 3I0 is greater than the minimum of any enabled 21N zone's 3_{I0} supervision level setting, begin the phase selector algorithm.

A buffer is used to track the pre-trigger load current, which is subtracted from the total current before checking the phase selector criteria.

During fault conditions the system frequency may change causing a drift in the angle difference being calculated by the phase selector. The locked pre-trigger load current vector is adjusted accordingly based on this angle difference between the pre-trigger positive sequence voltage and the positive sequence voltage during the fault. If the faulted positive sequence voltage shifts, the angle difference is taken into account. (i.e. the same angle relationship remains along the fault duration.)

Duration of the Phase Selector Supervision

The maximum blocking time to 21N for a phase-phase-ground fault is from 2.0 seconds to x seconds, where x is the maximum pickup delay in enabled 21P2 to 21P5, and then plus 8 cycles (8 cycles is the maximum breaker opening).

This ensures that if 21P did not trip on the phase-phase-ground fault for some reason, 21N is allowed to trip on this fault after this maximum blocking time delay has expired.

Ground Indicator in 21P Event Message

3_{I0} is checked against the minimum of the following settings:

- 21N1: 3_{I0} supervision when it's enabled
- 21N2: 3_{I0} supervision when it's enabled
- 21N3: 3_{I0} supervision when it's enabled
- 21N4: 3_{I0} supervision when it's enabled
- 21N5: 3_{I0} supervision when its enabled
- 50N Pickup level when it's enabled
- 51N Pickup level when it's enabled
- 50N_67F when it's selected as Scheme_Only or both ProLogic&Scheme

When 3_{I0} exceeds the minimum of the above values, a ground indicator "G" is put in the 21P event messages, e.g. "21P Trip ABG 123.1 km".

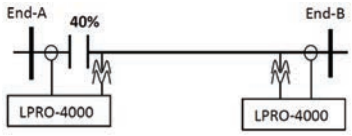
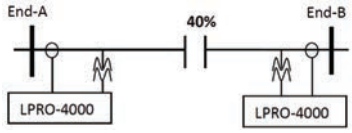
Series Capacitor on 21 Devices

When a series capacitor is added to a transmission line, performance of 21 devices can be affected significantly due to the effects such as sub-harmonics, voltage inversion and current inversions. Series capacitor algorithm provides enhanced performances against the effect of series capacitors. The algorithm consists of two parts namely (i) sub-harmonic removal filter and (ii) modified directional function.

The sub-harmonic removal filter is a 5th order Infinite Impulse Response (IIR) filter. Upon enabling the series capacitor option, sub-harmonic removal filter will be activated.

Based on compensation factor settings (i.e. if compensation factor > 0), directional function will be enabled. When the series capacitor is located at the end of the line, a compensation factor greater than zero should be used. In this case, voltage is measured from the line side PTs/CVTs. Reverse side voltage (estimated using line side voltage and phase currents) is used to determine the directionality. When the series capacitor is located at the far end of the line or middle of the line, the compensation factor setting should be set to zero.

Table 4.6: Series Capacitor Settings

Example	Settings: End A		Settings: End B	
	Series capacitor	% compensation	Series capacitor	% compensation
Capacitor located at the end of the line 	Enabled	40	Enabled	0
Capacitor located at the middle of the line 	Enabled	0	Enabled	0

Capacitance Coupled Voltage (CCVT) Transformer on 21 Devices

When a fault occurs, especially on a line with high source to impedance ratio (SIR), the CCVT secondary voltage can become quite different from the actual system voltage varying in both magnitude and phase due to the transient response of the CCVT. This transient response can cause device 21 overreach significantly. A special CCVT transient compensation algorithm (Patent Pending) has been included in L-PRO 4000 relay to address this issue.

The CCVT transient compensation algorithm uses a combination of techniques with digital filters, vector averages and other means to rebuild the correct voltage from the transient distorted voltage waveforms. This combination of techniques provides a secure method for detecting and correcting CCVT transient phenomena. On one hand, it improves the reach accuracy of 21 devices dramatically during the period of the CCVT subsidence transient. On the other hand, it will not sacrifice the relay operation speed very much. It does not add any additional delay when the SIR is low (<1.2). In the worst case, it adds about one cycle delay when the SIR is high (>15). For the operation time details, refer to “IED Specifications” in Appendix A.

This compensation algorithm can be enabled or disabled through settings. Note that this algorithm is applied to all 21 devices once it is enabled. For the applications without CCVTs, this compensation algorithm should be disabled so as to eliminate the possible additional delay introduced by this algorithm.

68 Power Swing

The Power Swing function can be used as a tripping or blocking function. This function consists of 2 sets of inner and outer impedance Zones on the R-X plane, for details see If the user selects Device 68 to block for Power Swing conditions, the relay energizes the front panel alarm LED when the 68 elements are blocking. If the user selects the 68 to trip for Power Swing conditions the relay energizes the front panel target light. on page 4-18. Set the Power swing zones to different values and to have the Power Swing function operate for different system conditions. The Power swing zones are quadrilateral characteristic and the reactance lines with the same angle as the angle chosen for the line positive sequence impedance. Outputs from the outer and the inner power swing zones are available on the output matrix for use with other types of Power Swing schemes or for monitoring.

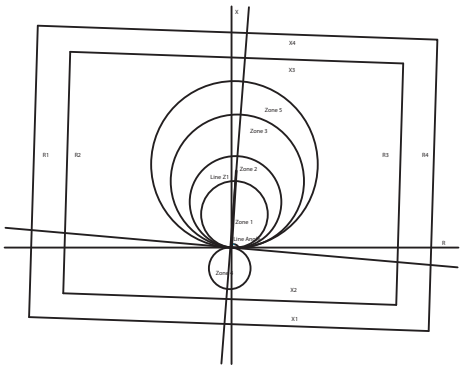


Figure 4.12: Power Swing Characteristic

The basic Power Swing scheme looks at the positive sequence impedance of the line with respect to the line loading. If the line loading causes the impedance to cross the outer Zone, an Power Swing timer is started. If the impedance does not cross the inner zone before this timer times out, the function produces an output (either a block or trip whichever is set) when the impedance crosses the inner Zone. The entire activity is supervised by an overcurrent function to prevent undesired operations for impedances far from the origin.

The logic has a timeout feature that prevents the blocking function from operating for an indefinite amount of time. Device 68 functions as either a blocking device or tripping device. The 68 Power Swing (68 Trip or 68 Block), 68 Inner and 68 Outer Zone logic points are available in the output matrix. These logic points are also logged as event messages in the event log, “Event Messages” in Appendix D In addition, the outputs from the inner and outer Zones are available for use with ProLogic to create any application scheme required.

If the user selects Device 68 to block for Power Swing conditions, the relay energizes the front panel alarm LED when the 68 elements are blocking. If the user selects the 68 to trip for Power Swing conditions the relay energizes the front panel target light.

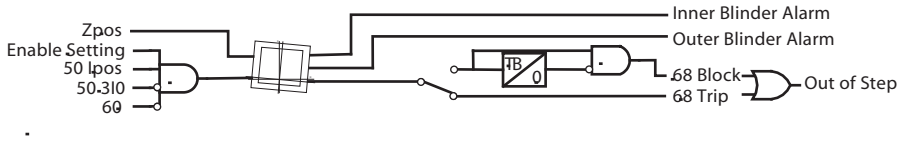


Figure 4.13: Power Swing Function

Table 4.7: 68 Power Swing Function Details	
Mode	Block, Off, Trip
Zone Blocking	
Zone 1 Blocking	Enable/Disable
Zone 2 Blocking	Enable/Disable
Zone 3 Blocking	Enable/Disable
Zone 4 Blocking	Enable/Disable
Zone 5 Blocking	Enable/Disable
Out of Step Swing Timer	0.00 to 1.00 seconds
I1 Supervision	0.5 to 50.0 A secondary (5A) 0.1 to 10.0 A secondary (1A)
3I0 Blocking	0.5 to 50.0 A secondary (5A) 0.1 to 10.0 A secondary (1A)
Blocking Reset Time	0.25 to 2.00 seconds
Left Hand Side (LHS) Blinder	
Outer (R1)	-100.0 to R2 ohms secondary (5A) -500.0 to R2 ohms secondary (1A)
Inner (R2)	R1 to R3 ohms secondary
Right Hand Side (RHS) Blinder	
Inner (R3)	R2 to R4 ohms secondary

Table 4.7: 68 Power Swing Function Details	
Outer (R4)	R3 to 100.0 ohms secondary (5A) R3 to 500.0 ohms secondary (1A)
Top Blinder	
Outer (X4)	X3 to 100.0 ohms secondary (5A) X3 to 500.0 ohms secondary (1A)
Inner (X3)	X2 to X4 ohms secondary
Bottom Blinder	
Inner (X2)	X1 to X3 ohms secondary
Outer (X1)	-100.0 to X2 ohms secondary (5A) -500.0 to X2 ohms secondary (1A)

Line Energization Supervision Logic

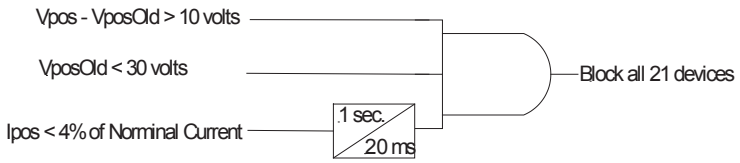


Figure 4.14: Line Energization Supervision Logic

Note: Vpos is the present positive sequence voltage.
VposOld is the positive sequence voltage at two cycles before.

The Logic shown in "Line Energization Supervision Logic" on page 4-20 has been introduced in order to prevent potentially erroneous operations of the 21 upon energizing of T-tapped transmission lines that have transformers connected and the PT connected on the line side of the breaker. This logic does not require any user setting.

In this logic, the present positive sequence voltage is compared with the positive sequence voltage of 2 cycles previously. In an energization situation, the VposOld would be near zero V and the present Vpos would be approximately the nominal. As time goes by the old Vpos gets updated with the nominal voltage and would eventually equal the present. When it gets within 10 V secondary the top input to the AND gate would reset, go to zero, and reset the blocking function.

The second input is the previous 2 cycle positive sequence voltage and has an undervoltage setting of 30 V. This input goes high to block the distance relays only if the positive sequence voltage from 2 cycles back was less than 30 V (approximately 50% nominal), so, for a line that has been previously energized and now experiences a fault, no distance relay blocking takes place.

The third input (the bottom one) produces an output only if the positive sequence line current is less than 4% nominal or 4.0% of 5 A secondary = 0.20

A secondary. If this current has been that low for the 1 second pickup time delay this input to the AND gate would go high. For a de-energized line this input would normally be high to allow the blocking scheme to operate if the other two inputs are high. This input along with input two are present to help prevent any distance relay blocking for a line that is in service and is now experiencing a line fault.

Switch-On-To-Fault (SOTF)

When energizing a line that has been out of service, the line may have a fault on it. If the line potential is derived from bus PTs, the distance relay function acts normal and operates for any fault that exists when the line is energized. If the line uses line PTs, the output of these line PTs is zero before energizing. Because there is no memory voltage, operation of the line distance functions may be undefined. To provide protection to detect faults when a line is first energized, the Switch-On-To-Fault function (SOTF) is involved.

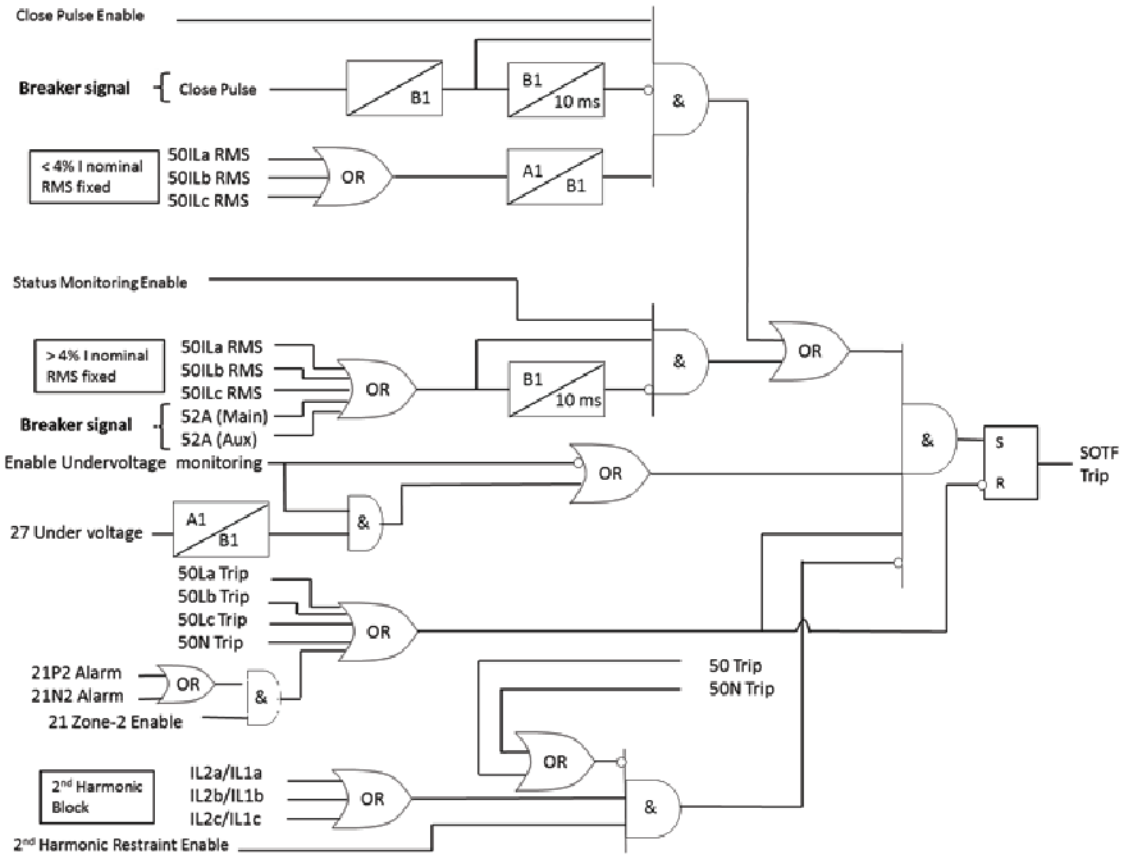


Figure 4.15: Switch-On-To-Fault (SOTF)

The logic diagram, Figure 4.15: Switch-On-To-Fault (SOTF) on page 4-21, shows how the circuit actually works. The SOTF function has options as Close Command or Status Monitoring.

Close Command

This method can be applied where the relay can get the Breaker Close command from control panel manual close switch (TNC) or SCADA Close command. This Close command should reach the relay as an External Input or a Virtual Input or ProLogics to initiate SOTF logic.

This method ensures that all the poles or any one pole are in dead condition for more than the A1 timer by checking the current level (i.e. lower than 4% of nominal), then it will enable the SOTF function.

Status Monitoring

This method can be applied where the relay can get Breaker status (52A). This Breaker Status Monitoring signal should reach the relay as an External Input or a Virtual Input to initiate SOTF logic.

This method will monitor all the pole statuses as well as each pole load current. The SOTF function is enabled whenever current value is changing from 0 to more than 4% of nominal or any pole Breaker status is changing from open to close.

Both options have a common Pick-up delay (i.e. timer B1), which will allow to extend the SOTF function enabled up-to the desired settable duration. Typically, this timer value shall be equal to Zone 2 time delay setting.

Under voltage supervision is available as an option to include into the logic. User can also enable or disable 21P2 and 21N2 monitoring.

During SOTF Enabled condition, if any 50 Trip or 50N Trip or Zone 2 (21N2 or 21P2) alarm picked up condition happens, then the relay will go for an instantaneous 3-pole SOTF Trip.

In addition to the above options, the SOTF function has a second harmonic restraint logic which allows the line to be more easily energized if the line is T-tapped with an online reactor or transformer. Energization of the line with the T-tapped device results in second harmonics that allows the line to be energized. If a fault exists that exceeds the line high set overcurrent devices, the line is allowed to trip.

Table 4.8: Switch-On-To-Fault Settings

Switch-On-To-Fault	Enable/Disable
Breaker Signal	Close Command/ Status Monitoring
Close Pulse	EI1 to EI 20, PL1 to PL24, VI1 to VI30 (This setting shall be enabled when the Breaker signal setting is selected as Close Command)
Main Breaker Status	EI1 to EI 20, PL1 to PL24, VI1 to VI30 (This setting shall be enabled when the Breaker signal setting is selected as Status Monitoring)
Aux Breaker Status	EI1 to EI 20, PL1 to PL24, VI1 to VI30 (This setting shall be enabled when the Breaker signal setting selected as Status Monitoring & ring bus configuration is enabled)

Table 4.8: Switch-On-To-Fault Settings	
Pole Dead Pick-up Timer (A1, Pick-up timer)	0.0 to 999.9 Seconds (This setting shall be enabled when the Breaker signal setting is selected as Close Command)
SOTF Enabled Duration (B1, Pick-up timer)	0.0 to 999.9 Seconds
Device 50 Pickup	0.5 to 50.0 A secondary (5 A) 0.1 to 10.0 A secondary (1 A)
Device 50N Pickup	0.5 to 50.0 A secondary (5 A) 0.1 to 10.0 A secondary (1 A)
Under-voltage Supervision Logic	Enabled/Disabled
Device 27 Pickup	1.0 to 120.0 (V)
Second Harmonica Restraint Logic	Enabled/Disabled
I_2/I_1 Ratio	0.0 to 10.0

Weak Infeed (WI)

Weak Infeed provides tripping if fault levels are too low to activate the distance units. If enabled, this function sends a permissive trip signal even if the fault level seen by the relay is very low as when the line breaker is open. The positive sequence and zero sequence voltage detectors allow the relay to echo back a permissive signal to allow the end with fault current to trip quickly without the need for an auxiliary b contact.

Table 4.9: Weak Infeed Settings	
Weak Infeed	Enable/Disable
Device 27 V1 Pickup	0.0 to 69.0 V secondary
Device 59 3V0 Pickup	0.0 to 100.0 V secondary
Zone 2/Zone 4 Reset Delay (TWD1)	0.02 to 0.20 seconds
Communication Cycle Reset Delay (TWD2)	0.02 to 0.20 seconds
Communication Reset Time Delay (TW3)	0.02 to 1.0 seconds

25/27/59 Sync Check

The relay can bring in voltages from both line and bus PTs. The Line Sync Check function, if enabled, looks at the voltage steady state angle between the line and bus PT voltage. If this angle is within a plus/minus specified value, (+/- 1 to 50 degree magnitude range of setting available), the function enables a definite time delay pickup (user-selectable 0 to 10 seconds) after which time an output is produced.

The line sync reference voltage is taken from a bus source. The relay can bring one single phase-to-neutral voltage. Logic within the relay allows the single-phase quantity to be either A, B or C phase. All unused single-phase inputs must be grounded for proper operation.

The Dead Main Live Auxiliary (DMLA), Live Main Dead Auxiliary (LMDA) and Dead Main Dead Auxiliary (DMDA) logic functions use fixed values of main and auxiliary positive sequence secondary voltages to determine the Sync Check condition. The voltage is fixed at 20 V secondary, voltages below 20 V are declared a dead state and voltages above 20 V are declared a live state.

When enabled, this function checks that the voltage angle between the line PT and bus PT are within a specified value. Use this function to ensure that closing a line to a system will result in acceptable power flow. The function uses positive sequence voltage, and therefore, can accommodate single-phase sources as well as 3-phase sources. If a single-phase source is used, it must be connected to the corresponding phase designation on the relay input. For example: If only a B-phase bus PT is available, it should be connected to the relay input B-phase terminals. In this example, the voltage and angle limit is 20 degrees with no pickup or drop out delay.

The Dead Main Live Auxiliary, Live Main Dead Auxiliary and Dead Main Dead Auxiliary logic functions use fixed values of main and auxiliary positive sequence secondary voltages to determine the sync check condition. The voltage is fixed at 20 V secondary. Voltages below 20 V are declared a dead state and voltages above 20 V are declared a live state.

Table 4.10: 25/27/59 Sync Check Settings

25 Sync Check	Enable/Disable
Maximum Voltage	60.0 to 138.0 V secondary
Minimum Voltage	40.0 to 69.9 V secondary
Angle Difference	1.0 to 50.0 degrees
Pickup Delay	0.00 to 10.00 seconds
Enable Frequency Difference	Enable/Disable
Frequency Difference	0.010 to 2.000 Hz
Main/Aux	
Enable Dead Main Live Aux. (DMLA)	Enable/Disable
Enable Live Main Dead Aux. (LMDA)	Enable/Disable

Table 4.10: 25/27/59 Sync Check Settings	
Enable Dead Main Dead Aux. (DMDA)	Enable/Disable

79 Recloser

The relay provides single-phase tripping and reclosing and 3-phase tripping and reclosing on the 4000 hardware platform.

The schemes available are user-programmable and consist of the following user setting options:

- 3-Phase Trip and Reclose Scheme
- 1-Phase/3-Phase Trip and Reclose Scheme

Please note that the user can select only one scheme at a time, although the user can change the scheme selected by using the setting groups within the setting software.

3-Phase Trip and Reclose Scheme

This scheme allows the relay to 3 phase trip always (even if the fault is single phase in nature) and reclose the 3 phases after a period of time. Up to 4 shots of reclosing is possible, depending upon the user recloser settings. The recloser logic control is capable of reclosing a single line breaker or two ring bus line breakers in a variety of sequences. The breaker reclosing sequence refers to the breakers as lead and follower breakers. The first breaker selected to reclose is called the lead breaker and the second breaker that is reclosed is called the follower. The reclosing can be done with or without synch check supervision. The output matrix is used to determine the inputs and the outputs to the 3-phase 79 recloser. The line breaker (s) is deemed to be open if the current through it is below 4% of the nominal current rating. (For a 5 A rated relay, this is 0.2 A rms)

3-Phase Reclose Timers

The lead breaker open interval times are settable for each reclosing shot (T1 to T4) for the 3-phase recloser. The follow breaker open time interval is common for each reclosure attempt. This follower breaker reclose time can be set to use the 79 follower timer TF or the 79 reset timer TD. See L-PRO 4000 Function Logic Diagram for details.

Lead or Follower Breaker Logic

The recloser setting options allow the lead breaker to be the main or auxiliary breaker. The recloser automatically selects the follower breaker into the lead position after the out of service time delay, TC is exceeded. If the follower breaker is removed from service, after the out of service time delay, TC, there is no further follower breaker reclose attempts. The breaker status is reset when the breaker status changes to closed for at least 10 seconds, or if the relay power supply is toggled Off then On again. A breaker is considered to be closed if

the current measured through it is greater than 0.2 A secondary for a 5 A relay. (4% I_n where I_n is either 1 A or 5 A)

External Reclose Blocking

The 79 also supports blocking from external devices via the output matrix and the internal 79 Lockout indication. The user can control the 79 remotely or locally with external or virtual inputs.

Lockout Indication

Lockout indication is provided for the lead and follower breaker. The lead and follower lockout indication is set for a fixed time delay pickup of the close signal time (TP) plus 1.0 second. When the recloser goes to the lead lockout condition, the breaker out of service timers are set to zero seconds and automatically pick up. If the recloser is in the lead lockout state, the logic remains in that state for setting (TD) seconds after the main or auxiliary breaker is manually closed. The follower lockout condition occurs when the follower breaker receives a close signal and the breaker remains open. If the recloser is in the follower lockout state, the logic remains in that state for setting (TD) seconds after the follower breaker is manually closed.

Table 4.11: 79 Recloser Settings

79 Recloser	Enable/Disable
Number of Shots	1 to 4
First Reclose (T1)	0.1 to 999.9 seconds
Second Reclose (T2)	1.0 to 999.9 seconds
Third Reclose (T3)	1.0 to 999.9 seconds
Fourth Reclose (T4)	1.0 to 999.9 seconds
Close Time (Tp)	0.1 to 1.0 seconds
Lockout Time (TD)	0.1 to 999.9 seconds
Initiate Reset (TDI)	0.0 to 999.9 seconds
Recloser Mode	Main only
Block Reset (TDB)	0.0 to 999.9 seconds
Follower Time (TF)	0.0 to 999.8 seconds
Breaker Out of Service (TC)	0.0 to 999.9 seconds
Follower Sequence Switch	
Close after the Recloser Follower Time (TF)	On/Off
Close after the Recloser Reset Time (TD)	On/Off
Sync Control	Enabled/Disable

The recloser provides flexibility with lead and follower breaker options. The lead breaker is in the main or auxiliary position. This allows the user to control the lead circuit breaker with complete Dead Main Live Auxiliary, Live Main Dead Auxiliary, Dead Main Dead Auxiliary or Live Main Live Auxiliary supervision (angle limit and voltage limit). The user also has the ability to control the 79 remotely or locally with external or virtual inputs. The 79 recloser monitors the breaker contact "a" status and automatically moves the follower breaker into the lead position when the lead breaker is removed from service, after an out-of-service time delay setting. For details of auto-recloser examples see "L-PRO Setting Example" in Appendix L.

Sync Control

The flexibility provided with device 79 allows the user to control 1 or 2 circuit breakers with complete Dead Main Live Auxiliary, Live Main Dead Auxiliary, Dead Main Dead Auxiliary or Live Main Live Auxiliary supervision (slip frequency). Sync control is provided on the lead breaker only, because the follower breaker always recloses after the lead breaker has successfully closed. ProLogic can be used to supervise follower breaker closing attempts if an external input is used to signal that the follower breaker has a valid sync check signal from an external device (e.g. PLC).

Operation of the Relay with the Single-Phase Trip and Reclose Scheme Setting

This setting allows the relay to trip only the faulted phase if the fault is single phase in nature, then initiate a reclose of that phase after a line dead time. The reason for this is that many faults are transient in nature, such as those caused by lightening. The trip of the faulted phase, and that the trip of the faulted phase then reclosing it some time later, should in many cases allow the line to return into service. The benefit of this scheme is that approximately one half of the power flow on the line (before the fault occurs) can be sent down the line during the open phase condition, promoting system stability and eliminating the need to resynchronize the line.

It should be noted that employing this scheme means that the high voltage line breakers must be capable of opening and reclosing in a single phase mode and that additional equipment such as line and neutral reactors must be installed on the line in order to allow the scheme to work correctly. A thorough systems study on the line and surrounding equipment must be performed in order that appropriate scheme settings be determined to obtain satisfactory performance of this scheme.

In operation, the Single-Phase Trip Setting blocks 79-3 from any attempts to reclose on a 3 Phase basis. If a single phase fault occurs on the line, the faulted phase is identified and only that phase is opened. After a period of time as defined by the pickup time of timer T1 in the single phase recloser 79-1, that phase will be reclosed. If the fault starts as a single phase fault and then evolves into a multiphase fault, or commutates to a different phase while the first phase is open, the line will 3 phase trip and reclosing will be inhibited. If the first single phase fault is detected, then reclosed upon, and if the fault persists, the line will 3-phase trip and lockout. Timer TD5 dropout time determines how soon a

subsequent single line to ground fault can occur after the first one in order for the line to attempt another single phase trip and reclosure. If a single phase fault is detected and that phase opens but fails to reclose before timer TM times out, the line will 3-phase trip and lockout. It is important therefore that timer TM be set longer in duration than the single phase recloser time. Only one single phase reclose is attempted. If upon reclosure the fault persists, before timer TD5 has had a chance to dropout, the line will 3-phase trip and lockout. To get the line out of a locked out state, the line must be manually reclosed and stay in service for longer than the single phase lockout timer TD reset.

Protection functions that can initiate a single phase trip and reclose are defined by the user in the output matrix setting screen. The user has full control to dictate which protection functions should initiate the recloser logic. Time delayed trips for instance may be considered backup functions where recloser initiation is undesired. In this case these types of operations can be set to block any attempted reclosures in any of the chosen reclosure schemes. These protection functions can also be set to initiate transient fault or dynamic swing recordings and breaker failure initiations on the output matrix as well.

During the single pole open condition while in the single pole tripping mode, unbalanced line load current will create negative and zero sequence line quantities. In order to override these unbalances, provisions have been made in the relay logic to allow the user to apply modified protective relay settings to the line protections that will be automatically applied while the line is in a phase open condition. These settings can be determined through load flow and fault study cases for the protected line. Once the line phase recloses, the protective settings that have been modified will return to their original settings. In this way, protection security can be maintained while the line goes through a single phase trip and reclose operation.

The drawing for the single phase reclosing logic is shown on the L-PRO 4000 Function Logic Diagram.

Single-Phase/3-Phase Trip and Reclose Scheme

With this scheme setting, the relay will trip and reclose a single phase for an initial Single Phase fault and will trip and reclose for a Three Phase or multiphase fault. Only one attempt to reclose will occur if the fault is permanent in nature before lockout will occur.

If sufficient time takes place between the first fault and subsequent new line faults, as determined by the TD4 and TD5 dropout times, the protection will try to keep the line in service by tripping and reclosing the line as required.

It should be noted that the relay has two types of reclosers, a single phase type 79-1 and a 3-phase type 79-3 recloser.

The single phase recloser has only one shot, determined by timer T1. This time delay applies for both the Single Phase Scheme and for the Single Phase/Three Phase Scheme settings.

The 3-phase recloser has a common setting for the first reclose of the Three Phase or the Single Phase/Three Phase Trip and Reclose Schemes.

Summary of Trip and Reclose Schemes

Three-Phase Trip and Reclose Scheme Setting

Provides 3-phase tripping for any type of line fault with up to four (4) shots of reclosure possible.

Single-Phase Trip and Reclose Scheme Setting

This scheme allows one shot of trip and reclose if the fault is single phase in nature. Multiple Phase line faults will 3-phase trip and lockout. Single phase faults occurring at a frequency less than TD5 reset time will result in 3-phase trip and lockout after first attempted reclose.

Single-Phase/MultiPhase Trip Scheme Setting

An initial line fault will cause the line to either 3-phase trip or single phase trip. If subsequent line faults occur before timers TD4 or TD5 reset, the line will 3-phase trip and lockout.

For any schemes selected, if a line goes into the lockout state, only a successful manual line reclose or a relay power supply reboot will reset the lockout logic.

The relay uses the current flow through a breaker to determine its status. If measured current flow is less than 4% nominal current (0.2 A for 5 A relay) the breaker is considered to be open.

59 Main/ Auxiliary Overvoltage

The relay provides overvoltage protection from both the bus and line PTs. Each input has two definite time delay functions.

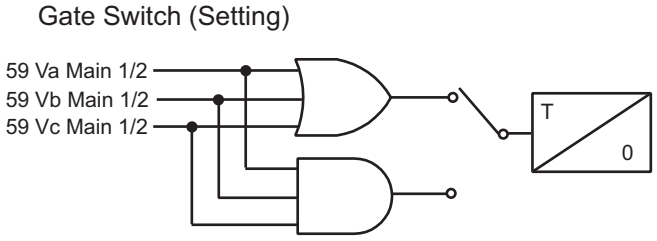


Figure 4.16: 59 Main Overvoltage

The definite time delay main overvoltage function, similar to the undervoltage function, looks at all 3 phase-to-neutral voltages. This function uses the RMS voltages to make this determination of overvoltage and is settable to an AND or OR logic.

The auxiliary overvoltage function operates exactly the same way as the main overvoltage function except that it uses the voltages from the auxiliary PT inputs.

Table 4.12: 59 Overvoltage Settings	
Main-1 / Main-2	Enable/Disable
Auxiliary-1 / Auxiliary - 2	Enable/Disable

Table 4.12: 59 Overvoltage Settings	
Gate Switch	AND or OR
Pickup	1.0 to 138.0 V secondary
Pickup Delay	0.00 to 10.00 seconds

59N Zero Sequence Overvoltage

The relay provides Zero sequence overvoltage protection from line side PT. The element operates on the residual voltage quantity 3V0. The element has one DTL and one Inverse Time stage

The device 59N Inverse Time provides three IEC inverse time curve types, three IEEE inverse time types of Zero sequence overvoltage protection and one user defined curve .The equation and the parameters of device 59N are listed below

Pickup

$$T(3V0) = TMS\left(B + \left(A / \left(\left(3V0/3V0_{pickup}\right)^{p} - 1\right)\right)\right)$$

Reset

$$T(3V0) = TMS\left(TR / \left(1 - \left(3V0/3V0_{pickup}\right)^{2}\right)\right)$$

Table 4.13: IEC and IEEE Curves				
NO	**Curve Type**	**A**	**B**	**P**
1	IEC Standard Inverse	0.14 (Fixed)	0.00 (Fixed)	0.02 (Fixed)
2	IEC Very Inverse	13.5 (Fixed)	0.00 (Fixed)	1.00 (Fixed)
3	IEC Extremely Inverse	80.00 (Fixed)	0.00 (Fixed)	2.00 (Fixed)
4	IEEE Moderately Inverse	0.0104 (Fixed)	0.0228 (Fixed)	0.02 (Fixed)
5	IEEE Very Inverse	3.880 (Fixed)	0.0963 (Fixed)	2.00 (Fixed)
6	IEEE Extremely Inverse	5.67 (Fixed)	0.0352 (Fixed)	2.00 (Fixed)
7	User-defined	0.0010 to 1000.0000	0.0000 to 10.0000	0.01 to 10.00

Table 4.14: Table 4.13: 59N Zero Sequence Overvoltage setting functions	
3V0 Pickup	Minimum level operates device 59N
Curve type	Sets the type of inverse time curve
TMS	Time scaling factor for inverse time curve

Table 4.14: Table 4.13: 59N Zero Sequence Overvoltage setting functions	
A, B, p	Parameters for defining the curve
TR	Factor for altering the reset time

Table 4.15: 59N Zero sequence overvoltage setting ranges	
59N Inverse Time Delay	Enable/Disable
Pickup (Volt)	5.00 to 150.00
Curve Type	See Table 4.12: IEC and IEEE curves
TMS	0.01 to 10.00
A	0.0010 to 1000.0
B	0.0000 to 10.0
p	0.01 to 10.0
TR	0.10 to 100.0
59N Definite Time Delay	Enable/Disable
Pickup (Volt)	5.00 to 150.00
Pickup Delay (Sec)	0.00 to 99.99

27 Main/ Auxiliary Undervoltage

The relay provides undervoltage protection from both the bus and line PTs. These functions are definite time delay functions.

The definite time main undervoltage function looks at the phase-to-neutral voltage of all 3 phases to determine an undervoltage condition. The fundamental RMS voltage is used for this calculation. If any of the phase-to-neutral voltages is below the set value, the function starts the definite time delay timer. The user can set this function to be an AND or OR logic.

The auxiliary undervoltage function operates exactly the same way as the main undervoltage function except that it uses the voltages from the auxiliary PT inputs.

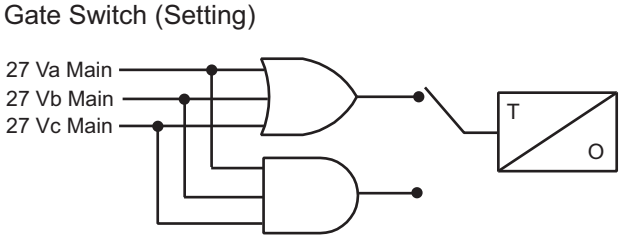


Figure 4.17: 27 Undervoltage

60 Loss of Potential (LOP)

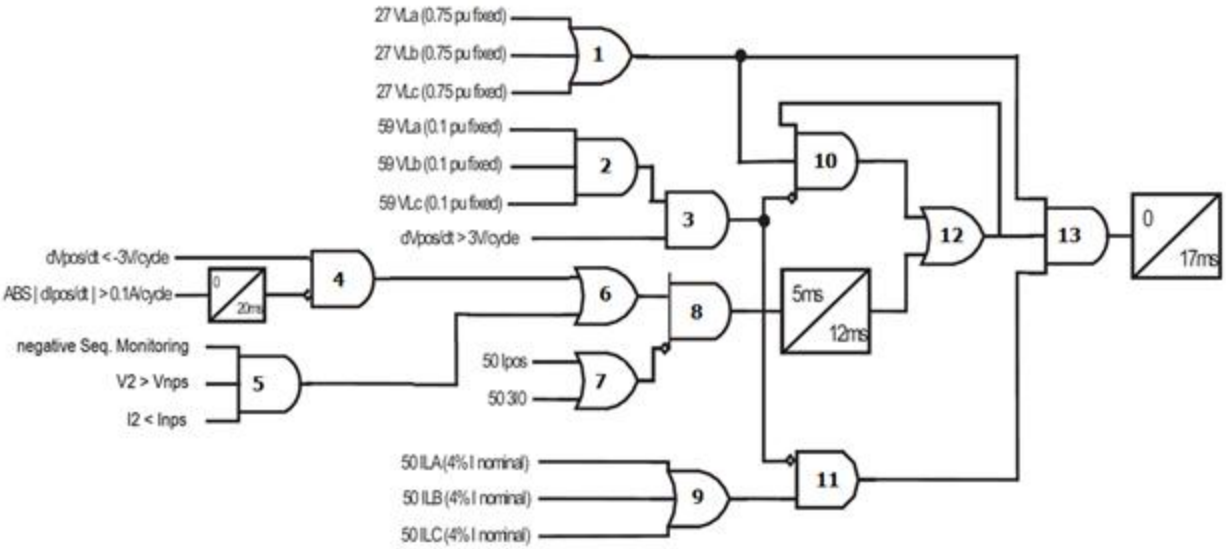


Figure 4.18: Loss of Potential Logic

The relay distance elements (21P and 21N) are supervised by both instantaneous non-directional overcurrent and the loss of potential (LOP) logic to pre-

vent false trip due to the loss of potential, where the phase distance elements are supervised by the delta current (i.e. Ia-Ib, Ib-Ic and Ic-Ia), and the ground distance elements are supervised by both the phase current and the zero sequence (3_{I0}) current.

The loss of potential (LOP) function uses rate of change values for the positive sequence voltage and current signal along with voltage and current supervision to detect loss of potential conditions. This function operates very fast and been field proven to block the distance elements during potential transferring between buses.

The function looks for a negative rate of change on the positive sequence voltage while determining if the positive sequence current is changing. A loss of potential in itself should result in only a loss of voltage or a negative rate of change of voltage. A fault results in a high rate of change of current as well. In some rare cases there is a negative rate of change of fault current, therefore we use an absolute rate of change of current. When the loss of potential condition is detected, it is latched until all the 3-phase voltages are above 75% or a positive rate of change of voltage is detected. So the circuit detects a loss of potential that results in a voltage of less than 75%. Select positive and zero sequence current blocking functions above the maximum load current, this ensures that LOP does not pick up on fault.

A dropout timer has been added on the di/dt signal (in front of gate 169) to ensure that the di/dt signal will not reset earlier than the dv/dt signal. This change improves the security of the algorithm in some particular fault situations.

If desired, negative sequence monitoring can be enabled to provide enhanced performance against PT fuse failure conditions occur during line energization.

Table 4.16: 60 Loss of Potential Settings

60 Loss of Potential	Enable/Disable
I1 Blocking	0.5 to 50.0 A secondary (5 A) 0.1 to 10.0 A secondary (1 A)
$3I_0$ Blocking	0.5 to 50.0 A secondary (5 A) 0.1 to 10.0 A secondary (1 A)
Negative Sequence Monitoring	Enable/Disable
Vnps	7.0 to 110 V
Inps	0.25 to 5.0 A secondary (5 A) 0.05 to 1.0 A secondary (1 A)

If this function is enabled and an AC Loss of Potential takes place, an output contact can be closed.

Loss of potential causes an alarm and distance elements will be blocked. Positive and zero sequence current settings provided will block this function for

faults. If voltage goes below 75% nominal (49.8 V) and the currents obtained do not exceed the settings, the loss of potential will be initiated.

Note that the positive and zero sequence current blocking level should be set above the maximum line current. This function is fast enough to provide blocking of the distance functions for schemes that use bus potential inputs that are sometimes transferred without the need for any external blocking inputs.

Table 4.17: Logic Gates - Loss of Potential Logic

Logic Gate #	Description (for details see Figure 4.18: Loss of Potential Logic on page 4-32)
1	When one of the phase-to-ground potentials falls below 0.75 pu, the logic element's output is HIGH.
2	Phase voltage AØ and BØ and CØ less than 0.1 pu will have output HIGH.
3	Logic element 2 HIGH and positive sequence rate of change voltage is not greater than 3 V/cycle - output HIGH, will invert into element 10 & 11 to Block tuning 10 & 11 off.
4	Detects LOP by checking a negative rate of change of positive sequence voltage below or less than 3 V/cycle - AND - an absolute value of rate of change of positive sequence current below or less than 0.1 A/cycle.
5	If negative sequence monitoring is enabled, detect LOP by checking high V2 and low I2.
6	Combines logic 4 & 5.
7	When 50Ipos or 503I0 exceed their set point and go HIGH (1) it will invert and block logic element 8.
8	LOP dection AND - not have a positive sequence load current (50 Ipos) above the setting.- OR - not have 3 times zero sequence fault current (3Io) above the setting of 3Io.
9	LOP is declared by this logic element (logic HIGH) when any of the phase currents are above 0.2 A.
10	Has an output when o/p from 1 is HIGH - AND - o/p from logic 12 is HIGH - AND - "NOT" logic 3 HIGH. (Positive sequence rate of change voltage is not greater than 3 V/cycle and not 3 phase voltage greater than 0.1 pu).
11	Has an output when o/p from 9 is HIGH - AND - positive sequence rate of change voltage is not greater than 3 V/cycle.
12	Has an output when o/p from 10 is HIGH - OR - timed o/p from logic 8 is HIGH.
13	Has a Loss of Potential (LOP) output when o/p from 1 is HIGH - AND - o/p from logic 11 is HIGH - AND - o/p from logic 12 is HIGH. The output is timed on drop out. This output is sent to other elements of the relay to give indication and block voltage elements, such as impedance from tripping falsely from loss of potential condition.

60 CT Supervision

The relay provides CT secondary circuit supervision function for both main and auxiliary CT's. The element operates on presence of negative sequence current Inps on main CT above the set vale and the absence of negative sequence voltage Vnps (below the set value, line PT) principle.

The auxiliary CT Supervision function operates exactly the same way as the main CT Supervision function except that it uses the Inps current from the auxiliary CT in-puts.

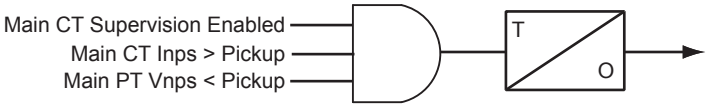


Figure 4.19: 60 CT Supervision

Table 4.18: 60 CT Supervision Settings

Main	Enable/Disable
Inps Pickup	0.25 to 5.00 A secondary (5A) 0.05 to 1.00 A secondary (1A)
Vnps Pickup	7.00 to 110.00 V secondary
Pickup Delay	0.03 to 99.99 seconds
Auxiliary	Enable/Disable
Inps Pickup	0.25 to 5.00 A secondary (5A) 0.05 to 1.00 A secondary (1A)
Vnps Pickup	7.00 to 110.00 V secondary
Pickup Delay	0.03 to 99.99 seconds

81 Frequency

The relay has 4 frequency devices available. Each frequency element can be set to operate either at a fixed level of under-frequency, a fixed level of over-frequency, or at a rate of change level (df/dt). The df/dt function can be set to operate for a positive rate of change or a negative rate of change. Each frequency element has a definite time delay setting to create a time delayed output. A fixed level of positive sequence voltage of 0.25 pu provides an undervoltage inhibit on each element

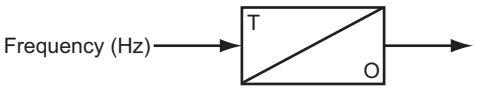


Figure 4.20: Frequency Fixed Level

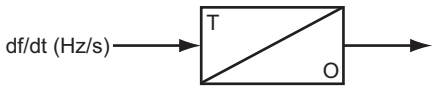


Figure 4.21: Frequency Rate of Change

Table 4.19: 81 Over/Under Frequency Settings

		Disabled/Fixed Level/Rate of Change
81.1	Pickup	50.000 to 59.995 or 60.005 to 70.000 (fixed level) -10.0 to -0.1 or 0.1 to 10.0 (rate of change)
	Pickup Delay	0.05 to 99.99 seconds (fixed level) 0.20 to 99.99 seconds (rate of change)
81.2	Pickup	50.000 to 59.995 or 60.005 to 70.000 (fixed level) -10.0 to -0.1 or 0.1 to 10.0 (rate of change)
	Pickup Delay	0.05 to 99.99 seconds (fixed level) 0.20 to 99.99 seconds (rate of change)
81.3	Pickup	50.000 to 59.995 or 60.005 to 70.000 (fixed level) -10.0 to -0.1 or 0.1 to 10.0 (rate of change)
	Pickup Delay	0.05 to 99.99 seconds (fixed level) 0.20 to 99.99 seconds (rate of change)
81.4	Pickup	50.000 to 59.995 or 60.005 to 70.000 (fixed level) -10.0 to -0.1 or 0.1 to 10.0 (rate of change)
	Pickup Delay	0.05 to 99.99 seconds (fixed level) 0.20 to 99.99 seconds (rate of change)

Four frequency elements are provided with adjustable definite time delays. Frequency is determined from the main voltage input (3 phase voltage).

50LS Overcurrent

The relay takes in currents from main, auxiliary CTs and 2 additional CT inputs, 50LS Input 3 and 50LS Input 4. These individual overcurrent devices can be used with ProLogic to create logic. 50LS Input 3 and 50LS Input 4 are not available in the Output Matrix.

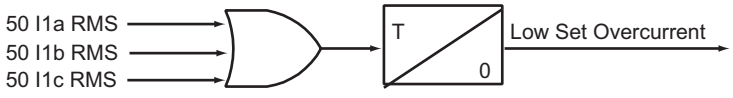


Figure 4.22: Low Set Overcurrent

Table 4.20: 50LS Low Set Overcurrent Settings	
Main (Input 1)	Enable/Disable
Pickup	0.10 to 50.0 A secondary (5A) 0.02 to 10.0 A secondary (1A)
Pickup Delay	0.00 to 10.00 Seconds
Auxiliary (Input 2)	Enable/Disable
Pickup	0.10 to 50.0 A secondary (5A) 0.02 to 10.0 A secondary (1A)
Pickup Delay	0.00 to 10.00 Seconds
Input 3	Enable/Disable
Pickup	0.10 to 50.0 A secondary (5A) 0.02 to 10.0 A secondary (1A)
Pickup Delay	0.00 to 10.00 Seconds
Input 4	Enable/Disable
Pickup	0.10 to 50.0 A secondary (5A) 0.02 to 10.0 A secondary (1A)
Pickup Delay	0.00 to 10.00 Seconds

50BF Breaker Failure

The Breaker Failure (BF) protection function detects breaker failures. There are 2 sets of breaker failure protection functions, 50BF Main and 50BF Auxiliary, one for each breaker. When breaker failure is initiated by a trip or other internal logic (user-settable through the output matrix) and the breaker current still exists, 2 timers (T1 and T2, user-settable) are started. When these timers are timed out and if the current still exists (which indicates breaker failure), the output of this function is set high. Use the 2 outputs of this function to trip another trip coil or the next level of breakers, such as bus breakers.

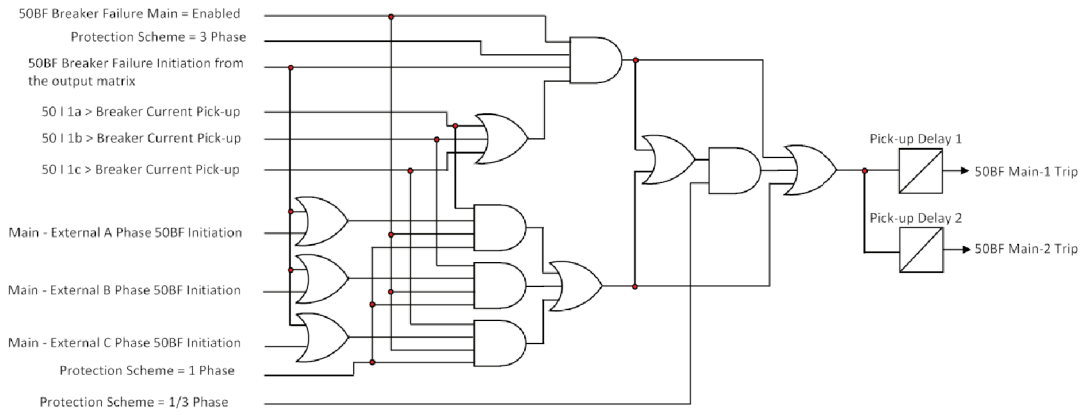

50BF Breaker Failure Main = Enabled
Protection Scheme = 3 Phase
50BF Breaker Failure Initiation from the output matrix
50 I 1a > Breaker Current Pick-up
50 I 1b > Breaker Current Pick-up
50 I 1c > Breaker Current Pick-up
Main - External A Phase 50BF Initiation
Main - External B Phase 50BF Initiation
Main - External C Phase 50BF Initiation
Protection Scheme = 1 Phase
Protection Scheme = 1/3 Phase
Pick-up Delay 1
50BF Main-1 Trip
Pick-up Delay 2
50BF Main-2 Trip

Figure 4.23: 50BF Main Breaker Failure

Table 4.21: 50BF Breaker Failure Settings	
Main	Enable/Disable
Pickup Delay 1	0.01 to 99.99 Seconds
Pickup Delay 2	0.01 to 99.99 Seconds
Breaker Current Pickup	0.10 to 50.0 A secondary (5A) 0.02 to 10.0 A secondary (1A)
Auxiliary	Enable/Disable
Pickup Delay 1	0.01 to 99.99 Seconds
Pickup Delay 2	0.01 to 99.99 Seconds
Breaker Current Pickup	0.10 to 50.0 A secondary (5A) 0.02 to 10.0 A secondary (1A)
Auxiliary (Input 2)	Enable/Disable
External Single Phase 50BF Initiate	
Main	
A Phase	Disabled, EI 1 to EI 20, PL1 to PL24
B Phase	Disabled, EI 1 to EI 20, PL1 to PL24

Table 4.21: 50BF Breaker Failure Settings	
C Phase	Disabled, EI 1 to EI 20, PL1 to PL24
Auxiliary	
A Phase	Disabled, EI 1 to EI 20, PL1 to PL24
B Phase	Disabled, EI 1 to EI 20, PL1 to PL24
C Phase	Disabled, EI 1 to EI 20, PL1 to PL24

The L-PRO breaker failure protection can be initiated by any protection function located within the L-PRO relay by initiating the BFI column in the Output Matrix screen. When the breaker failure function is initiated this way several modes of operation may occur.

1. If the 3 Pole tripping option for the relay is selected, initiation of the BFI column in the Output matrix will result in 3 pole breaker failure initiation. Output of the breaker failure function will then be a three pole output. The 3 pole BF initiation will occur regardless of the type of fault detected, single phase or multi-phase fault.
2. If the 1 Pole (single pole) tripping option for the relay is selected, initiation of the BFI column in the Output matrix will result in a 1 pole breaker failure initiation if a single phase trip by a protection function operates. If a multi phase fault occurs, a multi-phase protection function will be initiated and the BF initiation will be a 3 pole breaker failure. For this case all three poles of the breaker will be checked to see if they open correctly. Breaker failure operation will result in 3 pole backup breaker tripping just like the single pole BF initiation.
3. If the 1/3 Pole Scheme tripping option for the relay is selected, the breaker failure initiation will be a combination of (1) and (2) above, with single or three pole BF initiation as required by the fault detection.

The breaker failure function can also be initiated by an input to one of the external inputs from an outside protective relay or by a ProLogic input. This input can be a phase segregated input that can come from a single pole trip from an external relay and is shown on the Scheme Selector screen.

The breaker failure logic uses a current detector that is user settable in the 50BF Setting screen to determine whether a pole is open or closed in the range of 0.1 - 50 A secondary. There are two (2) breaker failure functions available per line breaker with adjustable pickup definite time delays from 0.01 to 99.9 seconds.

In any case, the output of the Breaker Failure function must be set to close output contacts to perform its function. This is done by mapping the BF output to the appropriate output contact in the Output Matrix screen.

Directional Control Used in Overcurrent Elements

Overcurrent elements (50/51/67, 50N/51N/67 and 46-50/46-51/67) can be monitored by the directional element used in the 21P/N elements or the directional functions that operate based on Alpha and Beta settings.

Operating boundaries of the Alpha and Beta based directional element are defined as shown in Figure 4.24: Directional Control on page 4-40.

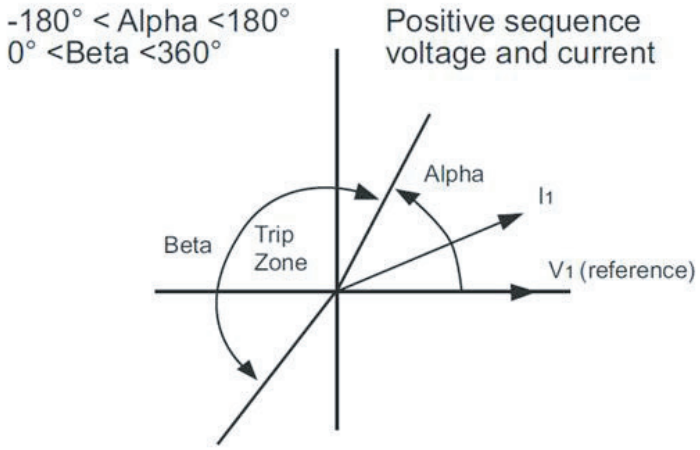


Figure 4.24: Directional Control

1. Alpha is the angle by which current leads or lags the positive real axis of V1 ref. Alpha is a positive in value if current leads V1 ref and vice versa.
2. Beta is the angle by which current leads or lags the Alpha boundary. Beta is set to a positive value if current leads Alpha angle and vice versa.

This directional function consists of following options.

Directional: Above directional control is applied. Since the positive sequence voltage is used , directionality is accurate even under 2- phase LOP conditions. Under 3-phase LOP conditions, function goes into the block mode.

Non-directional: Directional control is disabled.

Combined: Works as the directional option under all conditions except, 3-phase LOP. Under 3-phase LOP conditions, function goes into the non-directional mode.

50/51/67 Phase Overcurrent

Phase Overcurrent provides backup protection to the line. The user can define directional or non directional control on either 50 or 51 functions.

Device 51 provides 3 IEC inverse time curve types, 3 IEEE inverse time types of overcurrent protection and one user-defined curve. The equation and the parameters of Device 50/51/67 are listed below.

Table 4.22: IEC and IEEE Curves

No	Curve Type	A	B	p	TR
1	IEC Standard Inverse	0.14	0.00	0.02	13.5
2	IEC Very Inverse	13.50	0.00	1.00	47.3
3	IEC Extremely Inverse	80.00	0.00	2.00	80

Table 4.22: IEC and IEEE Curves					
4	IEEE Moderately Inverse	0.0103	0.0228	0.02	0.97
5	IEEE Very Inverse	3.922	0.0982	2.00	4.32
6	IEEE Extremely Inverse	5.64	0.0243	2.00	5.82
7	User-defined	[0.001, 1000]	[0.0, 10.0]	[0.01, 10.0]	0.1, 100

The equation of Devices 50/51/67 is given in Equation (3 and 4) below. The various parameters are defined in Table 4.23: 50/51/67 Phase Overcurrent Settings on page 42.

For I > pickup

$$T(I) = TMS\left[B + \frac{A}{\left(\frac{I}{Pickup}\right)^{p} - 1}\right] \quad (5)$$

For I < pickup

$$T(I) = TMS\left[\frac{TR}{1 - \left(\frac{I}{Pickup}\right)^{2}}\right] \quad (6)$$

Table 4.23: 50/51/67 Phase Overcurrent Settings	
50	Enable/Disable
Directional	Directional, non-directional, combined, Forward and Reverse
Pickup	0.50 to 150.00 A secondary (5A) 0.10 to 30.00 A secondary (1A)
Pickup Delay	0.00 to 99.99 seconds non-directional 0.01 to 99.99 seconds directional
51	Enable/Disable
Directional	Directional, non-directional, combined, Forward and Reverse
Pickup	0.25 to 25.00 A secondary (5 A) 0.05 to 5.00 A secondary (1 A)
Curve Type	For details see Table 4.22: IEC and IEEE Curves on page 40.
TMS	0.01 to 10.00
A	0.0010 to 1000.0000
B	0.0000 to 10.0000
p	0.01 to 10.00
TR	0.10 to 100.00
Directional Angle Setting	
Alpha	-179.90 to 180.00
Beta	0.10 to 360.00
Phase Setting Multiplier for Single-Phase Open Pole Condition	
50 Pickup Current Multiplier	0.10 to 2.00
50 Pickup Time Multiplier	0.10 to 2.00
51 Pickup Current Multiplier	0.10 to 2.00
51 Pickup Time Multiplier	0.10 to 2.00

50N/51N/67 Neutral Overcurrent

Neutral overcurrent provides backup protection for line to ground faults. The user can define directional or non directional control on either 50N or 51N functions. 51N can also be configured for use in the communication scheme. All the curve definitions are the same as the phase overcurrent except that this function uses 3I0 rather than phase current. The equation is:

For 3_{I0} > pickup

$$T(3I0) = TMS\left[B + \frac{A}{\left(\frac{3I0}{Pickup}\right)^{p} - 1}\right] \quad (7)$$

For 3_{I0} < pickup

$$T(3I0) = TMS\left[\frac{TR}{1 - \left(\frac{3IO}{Pickup}\right)^{2}}\right] \quad (8)$$

All parameters for Equations 5 and 6 are defined in Table 4.24: 50N/51N/67 Neutral Overcurrent Settings on page 43.

Table 4.24: 50N/51N/67 Neutral Overcurrent Settings

50N	Enable/Disable
Directional	Directional, non-directional, combined, Forward and Reverse
Pickup ($3I_0$)	0.25 to 50.00 (5 A) 0.05 to 10.00 (1 A)
Pickup Delay	0.00 to 99.99 seconds non-directional 0.01 to 99.99 seconds directional
51N	Enable/Disable
Directional	Directional, non-directional, combined, direction in scheme Forward and Reverse
Pickup ($3I_0$)	0.25 to 50.00 (5 A) 0.05 to 10.00 (1 A)
Curve Type	For details see Table 4.22: IEC and IEEE Curves on page 40.
TMS	0.01 to 10.00
A	0.0010 to 1000.0000
B	0.0000 to 10.0000
p	0.01 to 10.00
TR	0.10 to 100.00
Directional Angle Setting	
Alpha	-179.90 to 180.00

Table 4.24: 50N/51N/67 Neutral Overcurrent Settings	
Beta	0.10 to 360.00
Phase Setting Multiplier for Single Phase Open Pole Condition	
50N Pickup Current Multiplier	0.10 to 2.00
50N Pickup Time Multiplier	0.10 to 2.00
51N Pickup Current Multiplier	0.10 to 2.00
51N Pickup Time Multiplier	0.10 to 2.00

46-50/46-51/67 Negative Sequence Overcurrent

Negative Sequence Overcurrent provides further backup protection for any unbalanced faults. The user can define directional or non direction all control on either 46-50 or 46-51 functions. All the curve definitions are the same as the Phase Overcurrent. The only difference is that this function uses the negative sequence current (I2) rather than phase current. The equation is:

For I_2 > pickup

$$T(I2) = TMS\left[B + \frac{A}{\left(\frac{I2}{Pickup}\right)^{p} - 1}\right] \quad (9)$$

For I_2 < pickup

$$T(I2) = TMS\left[\frac{TR}{1 - \left(\frac{I2}{Pickup}\right)^{2}}\right] \quad (10)$$

Table 4.25: 46-50/46-51N/67Negative Sequence Overcurrent Settings	
46-50	Enable/Disable
Directional	Directional, non-directional, combined, Forward and Reverse
Pickup	0.50 to 50.00 (5 A) 0.10 to 10.00 (1 A)
Pickup Delay	0.00 to 99.99 seconds non-directional 0.01 to 99.99 seconds directional
46-51	Enable/Disable
Directional	Directional, non-directional, combined, Forward and Reverse
Pickup	0.50 to 50.00 (5 A) 0.10 to 10.00 (1 A)

Table 4.25: 46-50/46-51N/67Negative Sequence Overcurrent Settings	
Curve Type	For details see Table 4.22: IEC and IEEE Curves on page 40.
TMS	0.01 to 10.00
A	0.0010 to 1000.0000
B	0.0000 to 10.0000
p	0.01 to 10.00
TR	0.10 to 100.00
Directional Angle Setting	
Alpha	-179.90 to 180.00
Beta	0.10 to 360.00
Phase Setting Multiplier for Single Phase Open Pole Condition	
46-50 Pickup Current Multiplier	0.10 to 2.00
46-50 Pickup Time Multiplier	0.10 to 2.00
46-51 Pickup Current Multiplier	0.10 to 2.00
46-51 Pickup Time Multiplier	0.10 to 2.00

Adaptive Additional Delay for 50 O/C Elements

The relay provides an adaptive additional time delay (maximum 16 ms) response to the 50 O/C elements to prevent operation during RFI testing with minimal pickup set points and operation near pickup.

This adaptive delay is applied to: 50LS-1, 50LS-2, 50LS-3, 50LS-4, 50, 50N, 46/50.

If the Pickup Delay setting (Tp) < 20ms AND Pickup Level setting <$I_{nominal}$ (nominal current), an extra 8 ms delay is added. After this 8 ms timer expires, if I < threshold, the second 8ms extra delay will be added in addition to the original Tp. If I > threshold after the first 8ms timer expires, only Tp is used for the delay. (Note Tp is the setting which is less than 20ms, could be 0ms).

The threshold is equal to 2*PickupLevel if pickup is between 40%*$I_{nominal}$ and $I_{nominal}$ (i.e. between 2 A and 5 A for 5 ACT). The threshold is equal to 40%*$I_{nominal}$ if 2*PickupLevel < 40%*$I_{nominal}$. The threshold is equal to $I_{nominal}$ if 2*PickupLevel>$I_{nominal}$

Z Circle Trigger

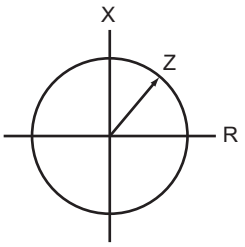


Figure 4.25: Z Circle Trigger

Table 4.26: Z Circle Trigger Settings	
Z Circle Trigger	Enable/Disable
Positive Sequence Impedance	0.1 to 50.0 ohms secondary (5 A) 0.5 to 250.0 ohms secondary (1 A)

The Impedance Circle Trigger (Z Circle Trigger) triggers the relay to record on a dynamic swing disturbance — only used to trigger a recording. This trigger is usually set outside the last protection zone used and blocked during LOP conditions.

Fault Locator

Whenever a fault occurs and the line trips, the fault locator calculates the fault type and the distance to the fault. This information is available from the front display of the relay or through Port 150, 123 or the SCADA port or through Relay Control Panel software. Fault locator information can also be captured optionally in event records. Fault locator can be enabled/disabled through settings (system parameters).

The fault locator is initiated by the following logic:

- 21 Trip
- 50N Trip
- 51N Trip
- Scheme Trip
- 21 Alarm (configurable)

The relay fault locator uses the Takagi method of fault location. The impedance calculated for a fault initiated by any of the above functions will be calculated and compared with the line impedance to calculate distance to fault.

Mutual Compensation

The fault locator has the ability to take into account mutual compensation for up to two lines in parallel with the protected line where the relay is applied.

The currents from the parallel line (s) is brought into the relay via spare current inputs I_{A3} and I_{A4}. The currents from up to two parallel lines can be added to determine the parallel line 3_{I0} current. There are two possible ways to get the parallel line 3_{I0} currents.

1. Connect all 3 phases of the first parallel line into the I_{A3} inputs. The currents are recorded by the relay if a recording initiation occurs and are added by the relay to obtain 3 I_{01} to be used in the line impedance to fault calculation. Alternatively, the neutral current from line 1 CTs can be connected to I_{A3}. This quantity is added with the other line 1 phase current inputs (which are $I_{B3} = I_{C3} = 0$ since no connection is made) to obtain line 1 residual 3_{I0} current. If this is done, the individual line 1 phase currents is not recorded by the relay.
2. Connect the currents from the second parallel line (if present) in a similar way to that of line 1.

ProLogic

ProLogic Control Statements

Using ProLogic, the relay can pick any of the protection functions, external inputs or virtual inputs and place them into Boolean-like statements. ProLogic handles up to 5 functions to generate one ProLogic statement; 24 statements are possible. The results from these statements are mapped to output contacts using the output matrix.

The ProLogic control statements are used to create Boolean-like logic. The relay can use any of the protection functions or external inputs combined with logic gates to create a ProLogic control statement. The possible gates are AND, NAND, OR, NOR, XOR, NXOR, and LATCH. The control can be time delay pickup and or time delay dropout, and can drive the front panel target LED. Twenty-four ProLogic control statements outputs are available and can be used in the output matrix to customize the relay to specific needs. Inputs to ProLogic are all the elements plus previous ProLogic statements for logic nesting usage.

The example, for details see Figure 4.26: ProLogic on page 4-47, shows A to E inputs are status points of devices that are user-selectable. Each ProLogic output can be given a specific name, pickup and reset time delay.

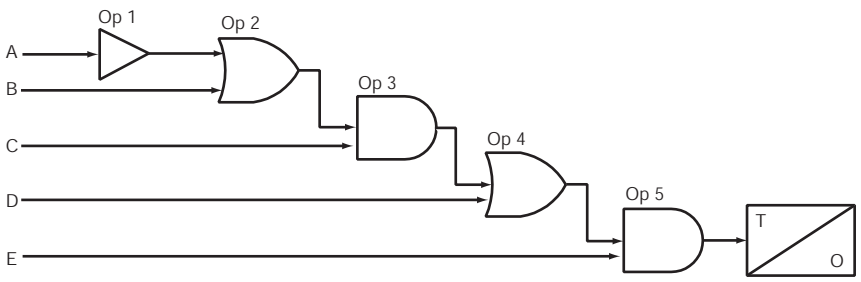


Figure 4.26: ProLogic

Table 4.27: ProLogic Setting Functions	
Name	Give the ProLogic a meaningful name
Pickup Delay	Delay time from pickup to operate
Dropout Delay	Delay time from dropout to a ProLogic status of low
A, B, C, D, E	Relay elements as input statements
Operators	Boolean-type logic gates

Group Logic

Group Logic Control Statements

The relay has 8 Setting Groups (SG). The user can change all relay setting parameters except the physical connections such as input or output parameters in each setting group. Setting group changes are performed by using any one of the 16 available Group Logic statements per setting group. The Group Logic statements are similar to the ProLogic statements with the following exceptions – the sole function is to activate one of the 8 setting groups and the processing is in a slower half second cycle. Group Logic inputs statements are driven from ProLogic or any external input or virtual input or from previous Group Logic statements. Each Group Logic statement includes 5 inputs (with Boolean statements), one latch state and one pickup delay timer. The Active Setting Group (ASG) is viewed from the Terminal Mode, the front panel or from a record stored by the relay, the ASG is stored with the record).

Group Logic Processing

The 16 Group Logic statements reside in a slower processing thread within the relay protection algorithms. The processing cycle happens once every half second (0.5 second). When using ProLogic statements remember that a latch or dropout timer should be used if the initiating condition does not last at least 0.5 seconds. In the example following, we will create a definite pulse length using ProLogic, for details see “L-PRO Setting Example” in Appendix L.

Default Setting Group

The relay uses Setting Group 1 as the factory default setting group and retains the current active setting group in memory. This allows the relay to use the last active setting group prior to interruption of relay power as the default setting group following power up.

Change Active Group

The user can at any time change the active setting group. When initiating a setting group change, this change takes precedence over an automatic setting group change.

The setting group can be changed using the Relay Control Panel, with either Change or Service access level, using the following path:

Relay Control Panel > Utilities > Settings Group

In this tab, choose desired setting group number and hit *Save*.

The setting group can also be changed using the relay display interface, after login in with the Change or Service access level, using the following path:

Main Menu > Utilities > Maintenance > Settings Group Control

In this screen, highlight the group number, and then hit *Edit*. Choose the desired setting group number, and then hit *Enter* with the cursor in the return character (bottom right).

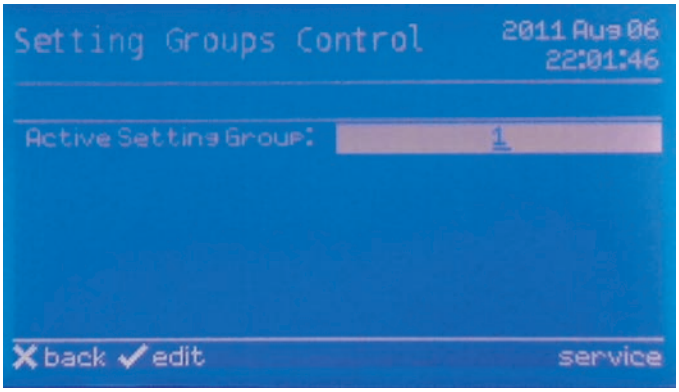


Figure 4.27: Settings Group Control

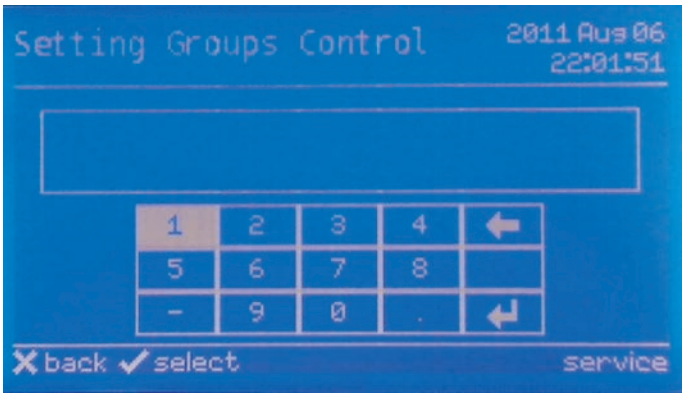


Figure 4.28: Settings Group Control change

The protection processor does not have any interruption in service.

Automatic Settings Change

Relay configuration changes during a relay-initiated setting; change does not disrupt the relay protection functions. Since the relay setting file does not change, the interface processor uses the new setting group ancillary setting information at the same time as the protection processor switches to the new setting group. An event is logged to show when the new setting group is in service.

4.1 Communication-Aided Scheme

The relay provides 4 communication aided tripping scheme options. Permissive Over-Reaching Transfer Trip (POTT), a combination of POTT with Weak Infeed (WI), Directional Comparison Blocking (DCB) or Permissive Under-Reaching Transfer trip (PUTT) are available to be used with external telecommunications devices for enhanced tripping of the protected line. The combination of phase distance, ground distance and neutral overcurrent elements provide flexible setting options for the selected communication aided tripping scheme.

Logic for 2 communication receivers can be used for 3 terminal lines or if the telecommunications use 2 separate communication channels. The user can set the communications receivers to use one of 20 external inputs or one of the 24 ProLogic statements. The same input cannot be shared between the 2 communication receivers.

The output matrix is used to configure the communications scheme send (permissive trip or block), and the communications scheme trip (local tripping) to any combination of the 21 available output contacts. The user-set dropout extension on output contacts is eliminated on any contact that is configured to operate for the communication scheme send signal; The user can provide the dropout time delay with timer setting TD3.

The communications aided tripping scheme options use the general distance and overcurrent protection functions of the relay, along with directional overcurrent elements specifically included in the scheme. These elements use the memory polarization as described in the “Relay Method of Memory Polarization” on page 4-7 and the directional element as described in “Directional Element” on page 4-10.

50/51N - OC Carrier Trip and Block Logic

The carrier trip logic is traditionally initiated by the Zone 2 distance elements, but the relay provides 2 directional neutral overcurrent elements that can be used in addition to the Zone 2 distance elements. The device 51N time overcurrent element, and the 50N/67F instantaneous overcurrent if enabled can be configured to drive the carrier trip logic. The 51N is configured in the 50N/51N screen, while the 50N/67F is configured in the scheme selector screen, both elements are forward directional elements.

The carrier block logic is traditionally initiated by the Zone 4 distance elements, but the relay provides one directional neutral overcurrent element that can be used in addition to the Zone 4 distance elements. The device 50N/67R,

if enabled, can be configured to drive the carrier block logic. The 50N/67R is configured in the scheme selector screen and is a reverse directional element.

The scheme selector can also be configured to enable the 50N/67F and 50N/67R directional overcurrent elements as inputs to ProLogic statements. The 50N/67F element can be set to either forward directional or non-directional when selecting the action, “ProLogic Only”.

If the pickup delay setting (Tp) < 9 ms, then 9 ms will be used for the delay. Otherwise Tp will be used for the delay. This change is always applied regardless of the direction setting (Non-dir, FWD, REV) and the 3_{I0} pickup level.

Note: If the directional element cannot determine a valid direction, the direction is set to “forward”, the 50N/67F may operate, and the 50N/67R element is blocked. See “Directional Element” on page 4-10.

Basic Logic

The basic selection does not provide any communication-aided logic for local or remote protections.

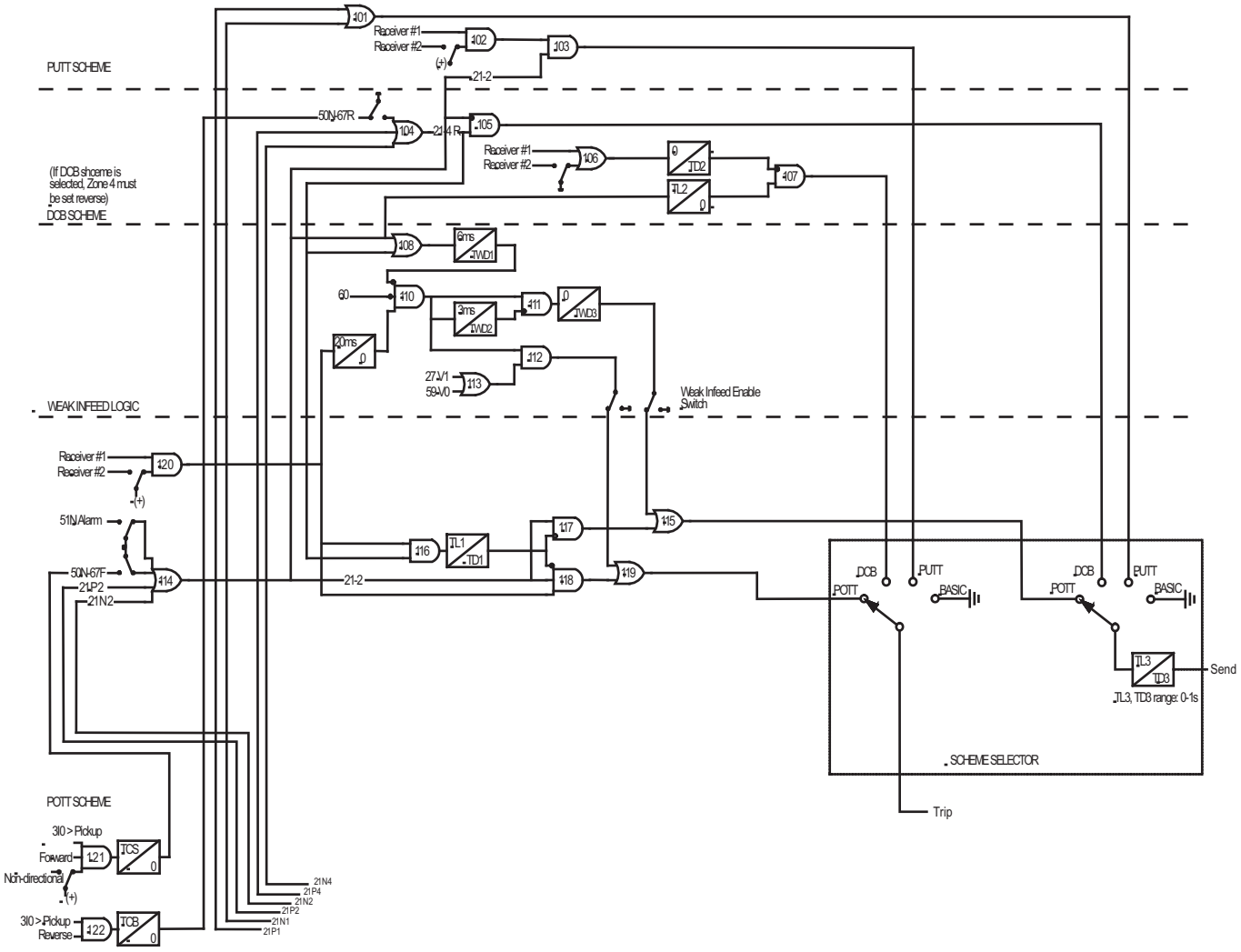


Figure 4.29: Communication-aided Scheme

POTT Logic

The POTT logic is used for tripping schemes where the local end over-reaches the remote end for forward fault conditions, for details see Figure 4.29: Communication-aided Scheme on page 4-52. The local end sends a permissive trip signal to the remote end when one of the forward directional elements operates. The scheme send signal (permissive transfer trip send) is time delayed by timer setting TL3; the local end is required to sense a forward fault for durations greater than TL3. The local end does not produce a scheme trip output unless the remote has detected a forward directional fault and sends the similar permissive trip signal to the local end. The local end senses a permissive trip receive signal and the scheme trip closes the output contacts and removes the fault contribution from the local end. The remote end acts in a similar fashion and the fault contribution is removed from the remote end.

Current reversal logic guards against incorrect permissive tripping for installations with parallel lines where one end of the un-faulted line is contributing fault current and the other end of the un-faulted line is over-reaching and sending a permissive trip signal. The local reverse directional elements are used with the permissive receive signal from the remote end to form the blocking logic. The blocking logic is time delayed by timer setting TL1; the local end is required to sense reverse faults while receiving the remote permissive trip for durations greater than TL1. The blocking logic continues to block the scheme send and scheme trip signals when the reverse fault detection or permissive trip receive signals go low. Timer setting TD1 determines the current reversal block extension time.

For line terminals with a weak source, fault conditions could occur on the protected line where no elements operate at the weak source. Weak infeed (WI) logic enables the relay to protect lines where one end of the line has no source or has a very weak source. The WI scheme can only be enabled if the user has selected the POTT scheme otherwise it is disabled. If enabled, the WI feature enhances the POTT tripping logic.

WI enables the POTT scheme to quickly isolate line faults where one end of the line has a high source of impedance.

During fault conditions where no weak source elements pick up the WI logic echoes back the permissive transfer trip signal received by the weak source. If a permissive transfer trip is received from the remote line end, AND 110, AND 111 and OR 115 echo a POTT signal back to the remote end. The permissive transfer trip signal is required to last for durations greater than 20 ms. A 3 ms time delay pickup and time delay dropout timer TWD2 determine the amount of time between permissive transfer trip receive signals that the scheme echoes back. If the permissive transfer trip receive signal is constantly high the WI logic only echoes back for a time equal to TWD3 plus 3ms. If the PT signal being received resets then starts up again, after timer setting TWD2, a new permissive transfer trip signal echoes back.

The WI logic blocks when forward or reverse faults are detected, the logic is also blocked for a loss of potential condition. During a reverse or a forward fault condition, the Zone 2, Zone 4, 51N, or 50N/67 elements could pick up. If any of these functions pick up, they block the WI scheme by putting a high input into inverted input of AND 110. The blocking condition is required last for

durations greater than 6 ms. The blocking logic continues to block the scheme send and scheme trip signals when the fault detection or loss of potential signals go low. Timer setting TWD1 determines the block extension time. TWD1 should be set to coordinate with the communication-reset time of the PT signal. It should be set greater than the time it takes for the remote end's Zone 2 to reset and for the PT channel to reset.

Timer setting TWD2 should be set to a time that prevents chattering of the communications channel. If TWD2 is allowed to reset before the remote end (strong source) clears the fault and stops sending the permissive transfer trip signal the WI echoes back another block of permissive transfer trip send.

The WI logic is also used to provide local tripping if both ends of the line are to be isolated. The line voltages provide supervision with a positive sequence under-voltage element (27V1) and a zero sequence over-voltage element (59V0). If a permissive transfer trip is received from the remote line end, AND 110, AND 112, OR 113 and OR 119 provide a local tripping signal.

DCB Logic

The DCB logic is used for tripping schemes where the local end over-reaches the remote end for forward fault conditions, for details see Figure 4.29: Communication-aided Scheme on page 4-52. Typically DCB is used when the communications link may be disrupted during fault conditions, for example power line carrier. The local end sends a block trip signal to the remote end when one of the enabled reverse directional elements operates. The scheme send signal (block trip send) is time delayed by timer setting TL3, the local end is required to sense a reverse fault for durations greater than TL3. If one of the forward directional elements operates the blocking logic does not operate. For forward directional fault conditions the DCB logic is time delayed by timer setting TL2. The forward fault condition has to last for durations greater than TL2. The local end does not produce a scheme trip output if the remote has detected a reverse directional fault and sends the similar block trip signal to the local end. The local end senses a block trip receive signal and the scheme trip logic is disabled with no intentional delay. Current reversal logic guards against incorrect local tripping for installations with parallel lines where one end of the un-faulted line is contributing fault current and the other end of the un-faulted line is reverse-reaching and sending a block trip signal. The local forward directional elements are supervised by the block receive signal from the remote end to form the blocking logic. The blocking logic reset is time delayed by timer setting TD2; the local end is required to receive the remote block trip for durations greater than 0 ms. The blocking logic continues to block the scheme trip signals when the block trip receive signal goes low. Typically the block reset timer TD2 is set longer than the forward directional elements reset time.

PUTT Logic

The PUTT logic is used for tripping schemes where the local end under-reach the remote end for close in forward fault conditions, for details see Figure 4.29: Communication-aided Scheme on page 4-52. The local end sends a permissive trip signal to the remote end when one of the forward directional elements operates (Zone 1 distance elements). The scheme send signal (permissive transfer trip send) is time delayed by timer setting TL3, the local end is required to sense a forward fault for durations greater than TL3. The remote end does not produce a scheme trip output unless a forward directional fault is detected and the local end has sent the permissive trip signal. The remote end senses a permissive trip receive signal and the scheme trip closes the output contacts and removes the fault contribution from the remote end. The remote end can act quicker for fault conditions where the Zone 2 faults would be time delayed unless the close in fault condition was not transferred by the scheme send.

4.2 Recording Functions

Introduction

The relay has high speed fault recording and logging functions to allow the user to analyze faults and to review the operation of the overall protection scheme. Slow speed swing recording can be used to analyze system stability. If the relay has reached its recording capacity, new records overwrite the oldest records.

Fault Recording

The relay provides DFR-quality fault recording, capturing input signal waveforms and external input states at a rate of 96 samples per cycle. Each record also contains the timing of the internal logic produced by the relay (e.g. Device 51 trip). Obtain this information by uploading the records from the relay via the Relay Control Panel file transfer process and view them with RecordBase View software.

The quantities recorded are:

- 18 analog channels (6 voltages and 12 currents) @ 96 samples/cycle which captures up to the 25th harmonic
- External inputs @ 1 ms resolution
- Protection element output signals @ 8 samples/cycle
- ProLogic signals @ 8 samples/cycle
- Active setting group

The recorded protection element output signals includes Phase segregated Start and Trip signals of the Distance trip, Backup Overcurrent, Back up Earth Fault, Overvoltage, Undervoltage and CB Fail Protection.

Parameters that are user-selectable with respect to recording transients:

- Record length (0.2 to 10.0 seconds => 12 to 600 cycles @ 60 Hz Base) with automatic extension to capture successive triggers
- Recorder triggering by any internal logic or external input signal (e.g. 52 A)
- Pre trigger time configurable between 0.10 to 2.00 seconds

Swing Recording

The relay records dynamic system responses allowing the user to analyze system stability and to provide a larger context for fault analysis. Swing records contain positive sequence phasor measurements and system frequency calculated at a rate of 1 phasor per cycle. Swing records can extend to 2 minutes in duration.

The quantities recorded are:

- Positive sequence impedance (magnitude)
- Positive sequence voltage (magnitude)
- Positive sequence current (magnitude)
- 3-Phase Reactive Power (Vars)
- 3-Phase Real Power (Watts)

Event Recording

The event recording provides permanent storage for the event log. The user can create an event record automatically or manually. When the event auto save is enabled, an event record is created approximately every 250 events.

The user can initiate an event manually through the Relay Control Panel.

Record Initiation

Recording can be initiated automatically by the relay when a fault or abnormal condition is detected. Set the relay to initiate a fault record on activation of any of its trip or alarm functions or on assertion of any external digital inputs.

The assignment of fault record initiation to the various relay functions is done through the relay's Output Matrix settings.

A recording can also be initiated manually through the Relay Control Panel. The commands Trigger Fault, Trigger Swing and Trigger Event are available under the following path:

Relay Control Panel > Records

Also the relay display provides the option to initiate Fault Recording, under the following path:

Main Menu > Records > Fault Recording

A swing record can take a couple of minutes to produce due to the long post-trigger time.

Record Duration and Extension

The length of each record is determined by the Record Length setting. Transient record lengths can be set between 0.2 and 10.0 seconds; swing record lengths can be set between 60 and 120 seconds. Pre-trigger times are configurable between 0.10 to 2.00 seconds for transient records and fixed at 30 seconds for swing records and are included as part of the normal record length.

The relay automatically extends a record as required to capture consecutive triggers that are close together. If a trigger occurs while a recording is in progress, the record is extended to include the full post-trigger time of subsequent triggers, up to a maximum length —12.0 seconds for transient records; 180 seconds for swing records. If a trigger occurs before the end of a record caused by a previous trigger, but too late to allow sufficient post-trigger time in a maximum extended record, a new overlapping record is created.

The normal record length settings are accessible under the Record Length heading of the relay settings, and can be set with the Offliner Settings software.

Record Storage

The relay compresses records on the fly, achieving a typical lossless compression rate of 4:1. As a result, the relay can store up to 75 x 2 second transient records, or up to 75 x 120 seconds swing records, or a combination of 75 transient, swing and optionally event records. If the storage is full, new records automatically overwrite the oldest, ensuring that the recording function is always available.

Record Retrieval and Deletion

A listing of stored records is available through the Relay Control Panel under the *Records > List* menu. The listing transfers records to a connected PC and deletes them from storage.

4.3 Event Log

The relay maintains a log of events in a 250 entry circular log. Each entry contains the time of the event plus an event description.

Logged events include trips, alarms, external input assertions plus internal events such as setting changes. Phase information is included in event messages where appropriate. For example, the event log entry for a device trip might be:

2010 Nov 21, 15:34:19.832: 51 on ABC Trip

The event log can be viewed in 2 ways:

Table 4.28: Event Log	
Front Panel	The front panel display shows events in abbreviated form (Trip and Alarm events only).
Relay Control Panel	The full event log is available through the Main Menu->Events of the Relay Control Panel
SCADA	The protocols included in the relay allow all the SCADA master access to the event data from the relay (Trip and Alarm events only).

This display is a snapshot of the event list which must be manually refreshed to display new events that occur while the display is up.

There is a list of Event Messages, for details see “Event Messages” in Appendix D

4.4 Fault Log

The L-PRO stores a log of faults in a 100 entry circular log. Each entry contains the time of the fault, fault type, faulted phase, fault quantities as per the below table. Fault log will be triggered only for trip condition and it won't log for an alarm condition.

Table 4.29: Fault Log

Fault Type	Fault Quantities
21P Phase Distance	- Fault Location - Fault Impedance Magnitude and Angle - Main VA/VB/VC Phasors - "Line" IA/IB/IC Phasors - Frequency
21N Ground Distance	- Fault Location - Fault Impedance Magnitude and Angle - Main VA/VB/VC Phasors - "Line" IA/IB/IC Phasors - Main Voltage Zero Sequence Phasor (3V0) - "Line" Current Zero Sequence Phasor (3I0) - Frequency
Distance Scheme Trip (POTT, PUTT, DCB)	- Fault Location - Fault Impedance Magnitude and Angle - Main VA/VB/VC Phasors - "Line" IA/IB/IC Phasors - Main Voltage Zero Sequence Phasor (3V0) - "Line" Current Zero Sequence Phasor (3I0) - Frequency
59 Main Over voltage 27 Main Under voltage	- Main VA/VB/VC Phasors
59 Aux Over voltage 27 Aux Under voltage	- Aux VA/VB/VC Phasors
50LS Main	- I1A/I1B/I1C Phasors
50LS Aux	- I2A/I2B/I2C Phasors
50-67 Trip 51-67 Trip	- "Line" IA/IB/IC Phasors
50N-67 Trip 51N-67 Trip	- "Line" Current Zero Sequence Phasor (3I0)
46-50/67 Trip 46-51/67 Trip	- "Line" Current Negative Sequence Phasor (3I2)

The fault log can be viewed in three ways:

- Relay Front HMI
- Relay Control Panel interface is in the Events tab

- 61850 SCADA protocol included in the L-PRO allow the SCADA client access to Trip event data

5 Data Communications

5.1 Introduction

Section 5 deals with data communications with the relay. First, the SCADA protocol is discussed, and it is then followed by the new IEC 61850 communication standard.

The SCADA protocol deals with the Modbus and DNP (Distributed Network Protocol) protocols. The SCADA configuration and its settings are described. The parameters for SCADA communications are defined using L-PRO 4000 Offliner software. Finally, details on how to monitor SCADA communications are given for maintenance and trouble shooting of the relay.

5.2 SCADA Protocol

Modbus Protocol

The relay supports either a Modbus RTU or Modbus ASCII SCADA connection. Modbus is available exclusively via a direct serial link. Serial Modbus communications can be utilized exclusively via serial Port 122, an RS-232 DCE DB9F port located on the back of the relay. An external RS-232 to RS-485 converter can be used to connect the relay to an RS-485 network. For details on connecting to serial Port, see “Communicating with the Relay Intelligent Electronic Device (IED)” on page 2-2 and “Communication Port Details” on page 2-15.

The data points available for Modbus SCADA interface are fixed and are not selectable by the user. Complete details regarding the Modbus protocol emulation and data point lists can be found in “Modbus RTU Communication Protocol” in Appendix E.

DNP Protocol

The relay supports a DNP3 (Level 2) SCADA connection. DNP3 is available via a direct serial link or an Ethernet LAN connection using either TCP or UDP.

Serial DNP communications can be utilized exclusively via serial Port 122. Port 122 is an RS-232 DCE DB9F port located on the back of the relay. An external RS-232 to RS-485 converter can be used to connect the relay to an RS-485 network. For details on connecting to serial Port, see “Communicating with the Relay Intelligent Electronic Device (IED)” on page 2-2 and “Communication Port Details” on page 2-15.

Network DNP communications can be utilized via physical LAN Port 119 or Port 120. Port 119 is available as a RJ-45 port on the front of the relay and as an RJ-45 or ST fiber optic port on the rear. Port 120 located on the rear of the relay is available as an RJ-45 or ST fiber optic port. DNP communications can be used with multiple masters when it is utilized with TCP. For details on connecting to the Ethernet LAN, see “Network Link” on page 2-5.

The data points available for DNP SCADA interface are user configurable. Complete details regarding the DNP3 protocol emulation and data point lists can be found in “DNP3 Device Profile” in Appendix F

SCADA Configuration and Settings

The parameters for SCADA communications may be defined using L-PRO 4000 Offliner.

If DNP3 LAN/WAN communications were chosen, the relay’s network parameters need to be defined. This is done via the Maintenance interface. Note that this effort may already have been completed as part of the steps taken to establish a network maintenance connection to the relay.

1. Establish a TUI session with the relay and login as **maintenance**. The following screen appears.

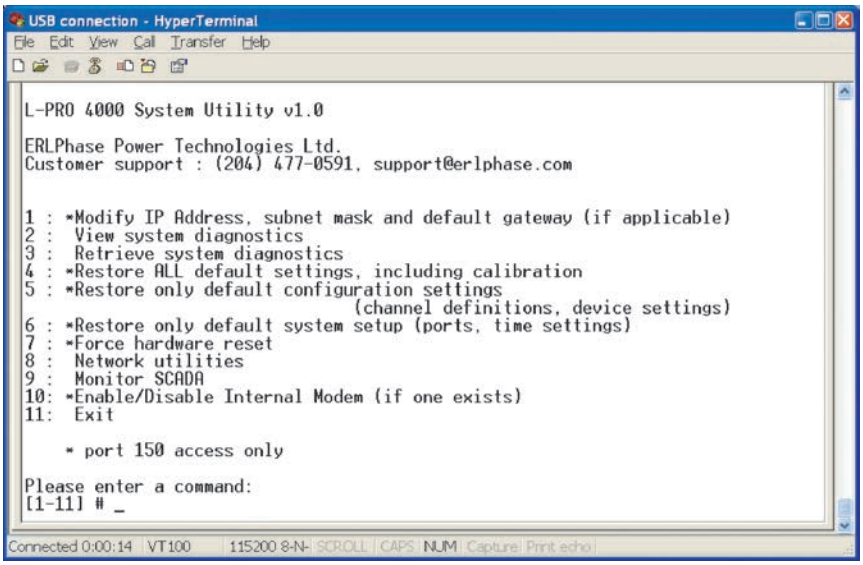

USB connection - HyperTerminal
File Edit View Call Transfer Help
L-PRO 4000 System Utility v1.0
ERLPhase Power Technologies Ltd.
Customer support : (204) 477-0591, support@erlphase.com
1 : *Modify IP Address, subnet mask and default gateway (if applicable)
2 : View system diagnostics
3 : Retrieve system diagnostics
4 : *Restore ALL default settings, including calibration
5 : *Restore only default configuration settings
(channel definitions, device settings)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: *Enable/Disable Internal Modem (if one exists)
11: Exit
* port 150 access only
Please enter a command:
[1-11] # _
Connected 0:00:14 VT100 115200 8-N- SCROLL CAPS NUM Capture Print echo

Figure 5.1: L-PRO 4000 System Utility

2. Select the first option by entering the number **1** followed by *Enter*. The following screen appears.

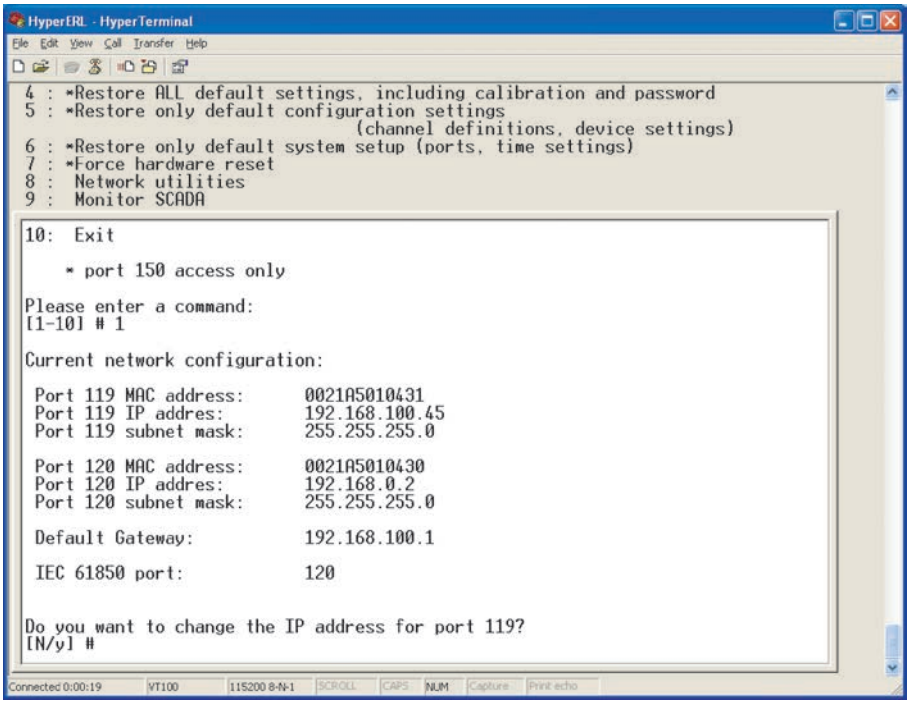

HyperERL - HyperTerminal
File Edit View Call Transfer Help
4 : *Restore ALL default settings, including calibration and password
5 : *Restore only default configuration settings
(channel definitions, device settings)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: Exit
* port 150 access only
Please enter a command:
[1-10] # 1
Current network configuration:
Port 119 MAC address: 0021A5010431
Port 119 IP addres: 192.168.100.45
Port 119 subnet mask: 255.255.255.0
Port 120 MAC address: 0021A5010430
Port 120 IP addres: 192.168.0.2
Port 120 subnet mask: 255.255.255.0
Default Gateway: 192.168.100.1
IEC 61850 port: 120
Do you want to change the IP address for port 119?
[N/y] #
Connected 0:00:19
VT100
115200 8-N-1
SCROLL
CAPS
NUM
Capture
Print echo

Figure 5.2: Change the network parameters as needed for the particular application

Offliner SCADA Configuration

Details on using the Offliner software are available in “To Install Software on the Computer” on page -xiii. Details on downloading a completed settings file to the relay are available in “Sending a New Setting File to the Relay” on page 6-6.

Open the Offliner application according to the instructions found in the indicated section and highlight the SCADA Communication selection. The screen appears as follows.

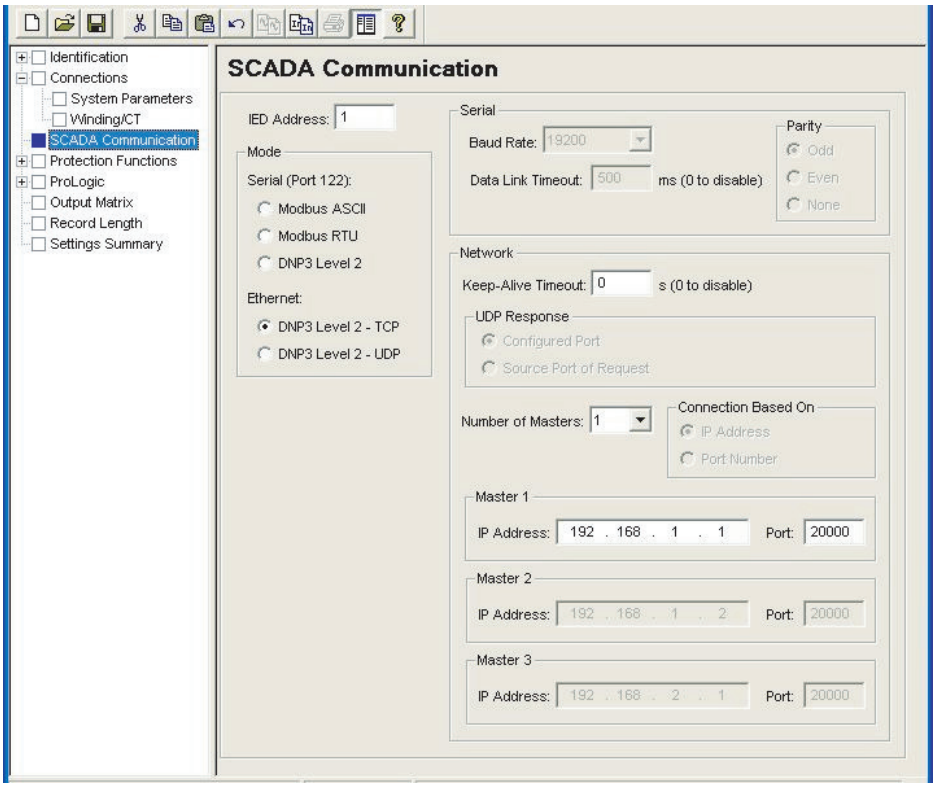


Figure 5.3: SCADA Communications

The configuration of SCADA communication parameters via the Offliner application is very intuitive. Several settings options are progressively visible and available depending on other selections. As noted before, there is no field to configure the number of data and stop bits. These values are fixed as follows:

- Modbus Serial – 7 data bits, 1 stop bit
- DNP Serial – 8 data bits, 1 stop bit

Monitoring SCADA Communications

The ability to monitor SCADA communications directly can be a valuable commissioning and troubleshooting tool. It assists in resolving SCADA communication difficulties such as incompatible baud rate or addressing. The utility is accessed through the Maintenance user interface.

1. Establish a TUI session with the relay and login as **maintenance**.
2. Select option 9 by entering the number **9** followed by *Enter*. The following screen appears.

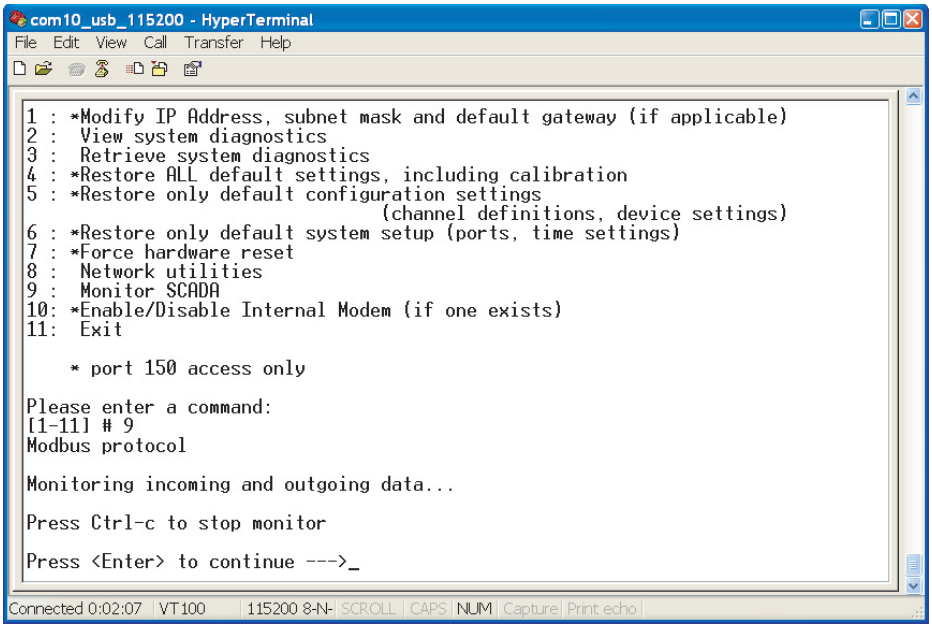

com10_usb_115200 - HyperTerminal
File Edit View Call Transfer Help
1 : *Modify IP Address, subnet mask and default gateway (if applicable)
2 : View system diagnostics
3 : Retrieve system diagnostics
4 : *Restore ALL default settings, including calibration
5 : *Restore only default configuration settings
(channel definitions, device settings)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: *Enable/Disable Internal Modem (if one exists)
11: Exit
* port 150 access only
Please enter a command:
[1-11] # 9
Modbus protocol
Monitoring incoming and outgoing data...
Press Ctrl-c to stop monitor
Press <Enter> to continue --->_
Connected 0:02:07 VT100 115200 8-N- SCROLL CAPS NUM Capture Print echo

Figure 5.4: Login Screen

3. Pressing the *Enter* key results in all SCADA communications characters to be displayed as hexadecimal characters. Individual exchanges are separated by an asterisk as the following sample illustrates.

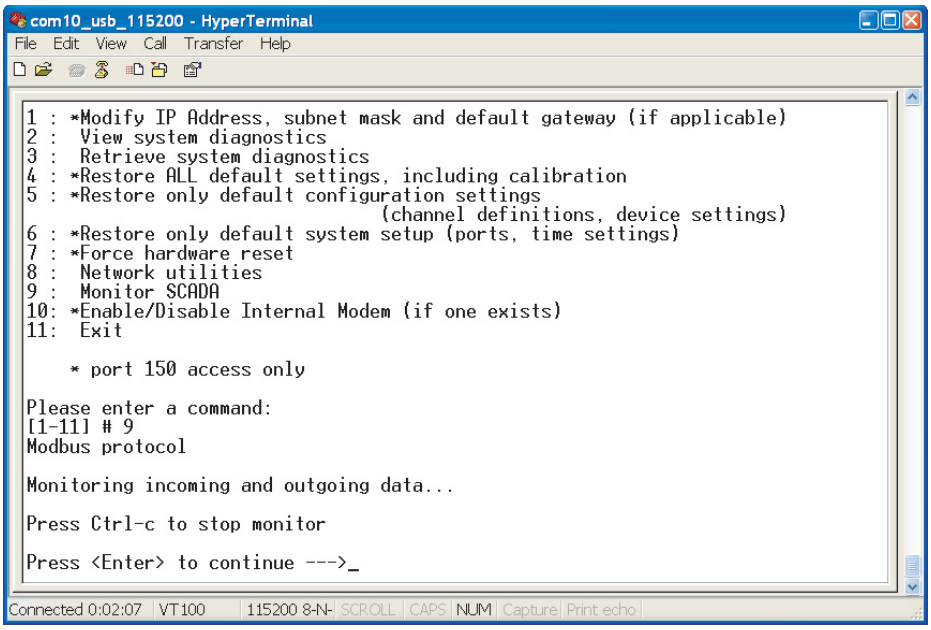

com10_usb_115200 - HyperTerminal
File Edit View Call Transfer Help
1 : *Modify IP Address, subnet mask and default gateway (if applicable)
2 : View system diagnostics
3 : Retrieve system diagnostics
4 : *Restore ALL default settings, including calibration
5 : *Restore only default configuration settings
(channel definitions, device settings)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: *Enable/Disable Internal Modem (if one exists)
11: Exit
* port 150 access only
Please enter a command:
[1-11] # 9
Modbus protocol
Monitoring incoming and outgoing data...
Press Ctrl-c to stop monitor
Press <Enter> to continue --->_
Connected 0:02:07 VT100 115200 8-N- SCROLL CAPS NUM Capture Print echo

Figure 5.5: Hyperterminal

4. Press *Ctrl-C* to end the monitor session.

5.3 IEC 61850 Communication

The IEC 61850 Standard

The Smart Grid is transforming the electrical power industry by using digital technology to deliver electricity in a more intelligent, efficient and controlled way. Embedded control and communication devices are central to this transformation by adding intelligent automation to electrical networks.

The IEC 61850 standard defines a new protocol that permits substation equipment to communicate with each other. Like many other well-known manufacturers, ERLPhase Power Technologies is dedicated to using IEC 61850-based devices that can be used as part of an open and versatile communications network for substation automation.

The IEC 61850 defines an Ethernet-based protocol used in substations for data communication. Substations implement a number of controllers for protection, measurement, detection, alarms, and monitoring. System implementation is often slowed down by the fact that the controllers produced by different manufacturers are incompatible, since they do not support the same communication protocols. The problems associated with this incompatibility are quite serious, and result in increased costs for protocol integration and system maintenance.

Implementation Details

The L-PRO 4000 conforms to IEC 61850-8-1, commonly referred to as Station Bus Protocol. Implementation includes the following documents (“IEC61850 Implementation” in Appendix N’ on page Appendix N-1):

- Protocol Implementation Conformance Statement
- Model Implementation Conformance Statement
- Tissues Conformance Statement

All configurable IEC61850 parameters are available via the Maintenance interface. Note that this effort may already have been completed as part of the steps taken to establish a network maintenance connection to the relay.

1. Establish a TUI session with the relay and login as **maintenance**. The following screen appears.

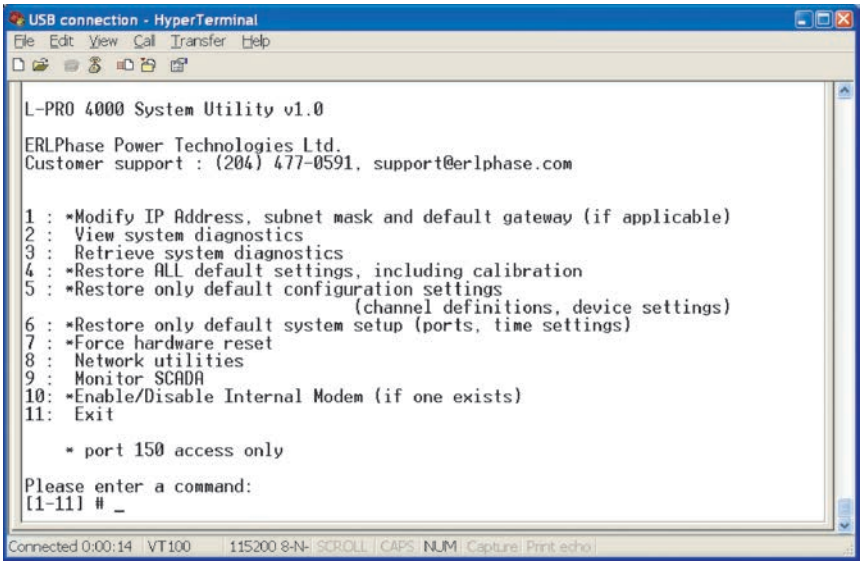

USB connection - HyperTerminal
File Edit View Call Transfer Help
L-PRO 4000 System Utility v1.0
ERLPhase Power Technologies Ltd.
Customer support : (204) 477-0591, support@erlphase.com
1 : *Modify IP Address, subnet mask and default gateway (if applicable)
2 : View system diagnostics
3 : Retrieve system diagnostics
4 : *Restore ALL default settings, including calibration
5 : *Restore only default configuration settings
(channel definitions, device settings)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: *Enable/Disable Internal Modem (if one exists)
11: Exit
* port 150 access only
Please enter a command:
[1-11] # _
Connected 0:00:14 VT100 115200 8-N- SCROLL CAPS NUM Capture Print echo

Figure 5.6: Maintenance Interface

2. Select the first option by entering the number **1** followed by <Enter>. The following screen appears.

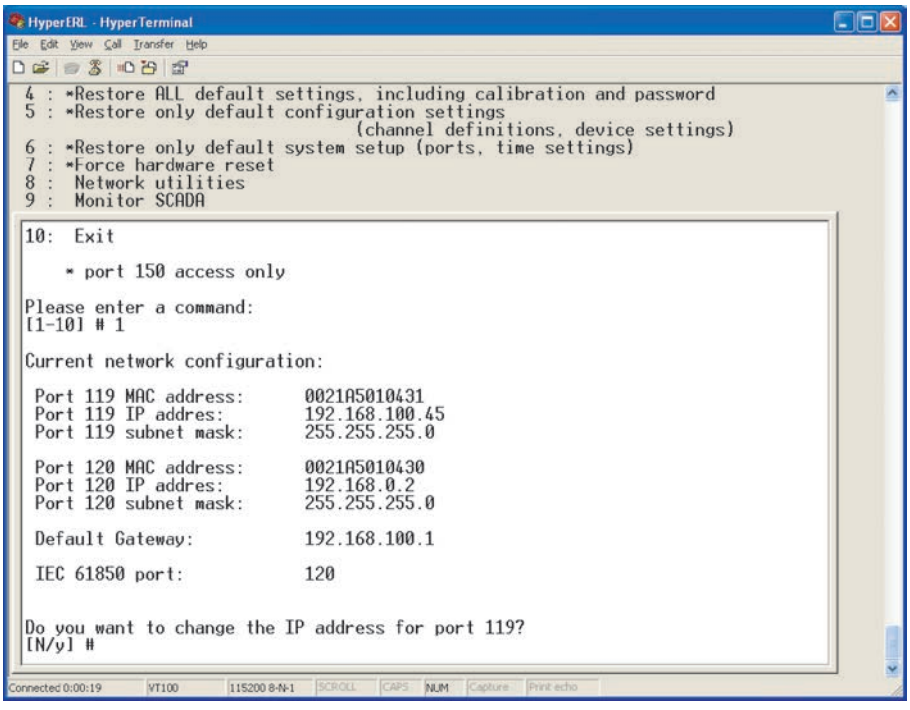

HyperERL - HyperTerminal
File Edit View Call Transfer Help
4 : *Restore ALL default settings, including calibration and password
5 : *Restore only default configuration settings
(channel definitions, device settings)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: Exit
* port 150 access only
Please enter a command:
[1-10] # 1
Current network configuration:
Port 119 MAC address: 0021A5010431
Port 119 IP addres: 192.168.100.45
Port 119 subnet mask: 255.255.255.0
Port 120 MAC address: 0021A5010430
Port 120 IP addres: 192.168.0.2
Port 120 subnet mask: 255.255.255.0
Default Gateway: 192.168.100.1
IEC 61850 port: 120
Do you want to change the IP address for port 119?
[N/y] #
Connected 0:00:19 VT100 115200 8-N-1 SCROLL CAPS NUM Capture Print echo

Figure 5.7: Change the network parameters as needed for the particular application

Note that unit's IP address can be used on the IEC61850 client side for unique unit identification instead of a physical device "PD Name". The publisher configuration is fixed and defined in the ICD file and available for reading to any IEC61850 client. Subscriber functionality is also fixed and supported for the Virtual Inputs only.

6 Offliner Settings Software

6.1 Introduction

This section deals with the Offliner Settings software. The Offliner settings software is used to create relay settings on a personal computer. Offliner provides an easy way to view and manipulate settings. Offliner supports all firmware versions and has the capability to convert older setting versions into newer ones.

In this section, first, the Offliner features are presented. The menu and toolbar are discussed and this is followed by a description of the Graphing and Protection functions.

Next, the Offliner features for handling backward compatibility with previous software versions is described. Also described are methods of converting a Settings File, sending a new Settings File to the relay and creating a Settings File from an older version of the software.

Next, the RecordBase View and RecordGraph to analyze the records from a relay are described.

This is followed by a lengthy description of the main branches from the Tree View. This section provides all information for Identification, System Parameters, SCADA Communication, DNP Configuration, SCADA Settings summary, Record Length, Setting Groups, ProLogic, Group Logic, Output Matrix and Settings summary.

Finally, a description of how the settings on the relay can be viewed through the RecordBase View analysis software is provided.

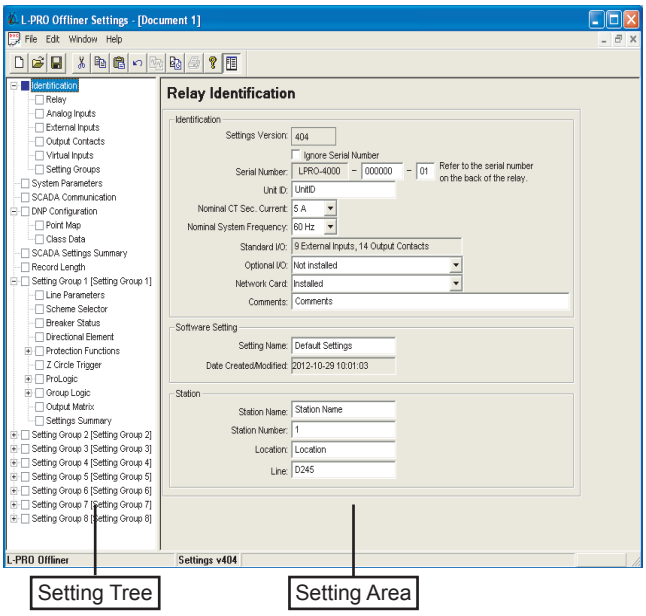


Figure 6.1: Opening Screen

6.2 Offliner Features

Menu and Toolbar

The Offliner software includes the following menu and system tool bar. “Top Tool Bar” on page 6-2 describes the details.

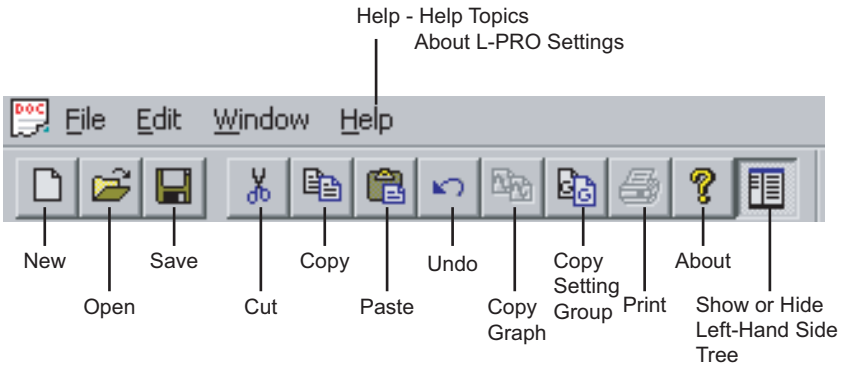


Figure 6.2: Top Tool Bar

Table 6.1: Windows Menu

Windows Menu	**Sub Menu**	**Comment**
Document Menu (Icon)	Restore	Restores active window to previous size
	Move	Allows user to move active window
	Size	Allows user to resize active window
	Minimize	Makes the active window as small as possible
	Maximize	Makes the active window as large as possible
	Close	Closes the active Offliner setting document
	Next	Switches to the next open Offliner setting file, if more than setting file is being edited

Table 6.1: Windows Menu		
File Menu	New	Opens up a default setting file of the most recent setting version
	Open	Open an existing setting file
	Close	Closes the active Offliner setting document
	Save	Saves the active setting file
	Save As	Saves the active setting file with a new name or location
	Convert to Newer	Convert an older setting version to a newer version.
	Print	Prints graphs or setting summary depending on active screen
	Print Preview	Provides a print preview of the setting summary
	Print Setup	Changes printers or print options
	1-6	The six most recently accessed setting files
	Exit	Quits the program
Edit Menu	Undo	Undo last action
	Cut	Cut the selection
	Copy	Copy the selection
	Paste	Insert clipboard contents
	Copy Graph	Copy the graph for the active screen to the clipboard
	Copy Setting Group	Copy values from one Setting Group to another
Window	Cascade	Cascades all open windows
	Tile	Tiles all open windows
	Hide/Show Tree	If this option is checked then the LHS Tree view will be hidden
	1-9, More Windows	Allows access to all open Offliner setting files. The active document will have a check beside it
Help	User Manual	Displays the user manual
	About Offliner	Displays the Offliner version
Toolbar		
New	Create a new document.	Create a new document of the most recent setting version
Open	Open an existing document.	Open an existing document
Save	Save the active document.	Save the active document

Table 6.1: Windows Menu		
Cut	Cut the selection.	Cut selection
Copy	Copy the selection.	Copy the selection
Paste	Insert clipboard contents.	Insert clipboard contents
Undo	Copy graph to clipboard.	Undo last action
Copy Graph		Copy the graph for the active screen to the clipboard
Copy Setting Group	Copy values from one Setting Group to another.	Brings up the Copy Inputs dialog box
Show/Hide LHS Tree		If this option is checked then the LHS Tree view will be hidden
Print	Print active document.	Prints Graphs or the setting summary, depending on which seen is selected
About	Display program information.	Displays the Offliner version

6.3 Offliner Keyboard Shortcuts

The following table lists the keyboard shortcuts that Offliner provides.

Table 6.2: Keyboard Shortcuts

Ctrl+N	Opens up a default setting file of the most recent setting version
Ctrl+O	Open an existing setting file
Ctrl+S	Saves the active setting file
Ctrl+Z	Undo
Ctrl+X	Cut
Ctrl+C	Copy
Ctrl+V	Paste
Ctrl+F4	Closes the active Offliner setting document
Ctrl+F6	Switches to the next open Offliner setting file, if more than one setting file is being edited
F6	Toggles between the LHS Tree view and HRS screen
F10, Alt	Enables menu keyboard short-cuts
F1	Displays the user manual

Graphing Protection Functions

Grid On/Grid Off

The graph can be viewed with the grid on or off by clicking the Grid On or Grid Off button. A right-click on the trace of the curve gives the user the x and y coordinates.

Refresh

This button will manually refresh the graph if it has been zoomed.

Print Graph

To print a particular graph, click the *Print Graph* button.

Zoom on Graphs

Graphs can be zoomed to bring portions of the traces into clearer display. Left-click on any graph and drag to form a small box around the graph area. When the user releases the mouse, the trace assumes a new zoom position determined by the area of the zoom coordinates.

To undo the zoom on the graph, click the Refresh button.

Displaying Co-ordinates

At any time the user may right-click on the graph to display the co-ordinates of the point the user selected.

6.4 Handling Backward Compatibility

Offliner Settings displays the version number in the second pane on the bottom status bar. The settings version is a whole number (v1, v2, v3, v4, etc.).

The Offliner Settings is backward compatible; open and edit older settings files and convert older settings files to a newer version. Offliner settings handles forward conversion only — it converts an older setting file to a newer setting file.

Converting a Settings File

1. Open the setting file to convert.
2. In the *File* menu, select *Convert to Newer...* and then select the *version x* (where x is the newer version). A dialog box pops up prompting Offliner for a new file name. Use either the same file name or enter a new file name. The conversion process inserts default values for any newly added devices in the new setting file. When the conversion is complete, Offliner Settings displays the new file.

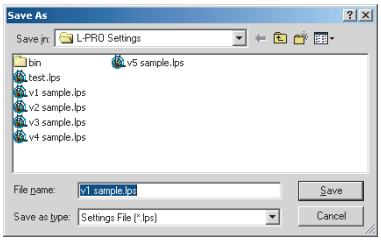


Figure 6.3: Converting Setting Files

Sending a New Setting File to the Relay

1. Make sure the settings version and the serial number of the relay in the setting file match. The relay will reject the setting file if either the serial number or the settings version do not match.

A “serial number discrepancy” message may appear. This is to ensure that the user is aware of the exact relay in which settings are to be loaded. If this happens, check the relay serial number using the terminal mode ID menu item. Type this serial number into the L-PRO Serial No. box in the Identification tab display area of Offliner Settings. Alternately the user may check the Ignore Serial Number check box to bypass serial number supervision.

2. Check the serial number and the settings version of the relay. The Device Serial Number and Required Settings Version on the Identification screen indicate the serial number and the settings version of the relay.

Creating a Setting File from an Older Version

1. Offliner Settings displays a default setting file on start up showing the settings version in the bottom status bar. As an example L-PRO Offliner is shipped with a set of default sample files of older settings versions. These sample files are “v1 sample.lps”, “v2 sample.lps”, “v3 sample.lps”, etc. Each sample file contains default values of an older settings version. For a new installation these sample files are placed in the default directory *C:\Program Files\ERLPhase\L-PRO Offliner Settings*, or the user can choose the path during the Offliner software installation. If an older version of L-PRO Offliner was previously installed on the PC, then the default directory may be *C:\Program Files\APT\L-PRO Offliner Settings*. Open a sample file of the desired version. Use *File/Save As* to save the sample file to a new file name. Then edit the setting file and the serial number, save it and load it into the relay.

6.5 RecordBase View Software

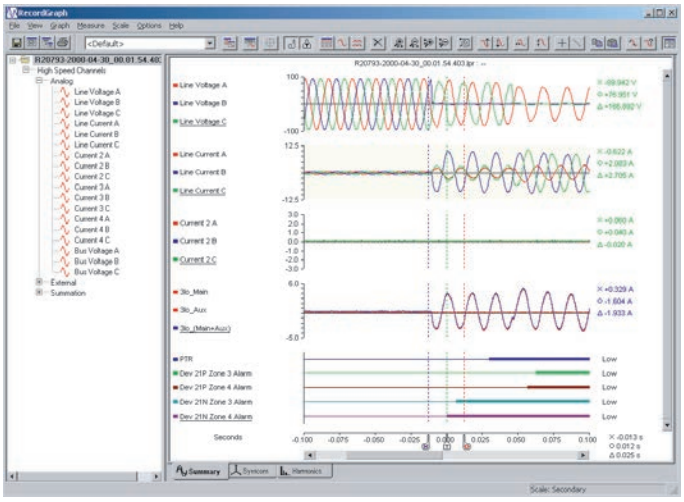


Figure 6.4: RecordGraph

Use RecordBase View and RecordGraph to analyze the records from a relay.

1. Set the receive directory on the terminal program to point to a convenient directory on the PC's hard disk or network. For example with HyperTerminal, select *Transfer>Receive File* to set the receive directory.
2. Select one or more records on the relay using the *List* function in the Terminal Mode's *Records* menu.
3. Initiate transfer of the selected records by selecting *R* on the keyboard.
4. Start the RecordBase View program and use the *File>Open* menu command to open the downloaded record files located in the receive directory specified in step 1.

For further instructions refer to the RecordBase View Manual at the back of the printed version of this manual.

6.6 Main Branches from the Tree View

This section will describe the tree view, which provides access to the various setting screens. This section will not describe individual settings, but will provide a general description of where to find the individual settings. For a detailed description of the individual settings see Chapter 4.

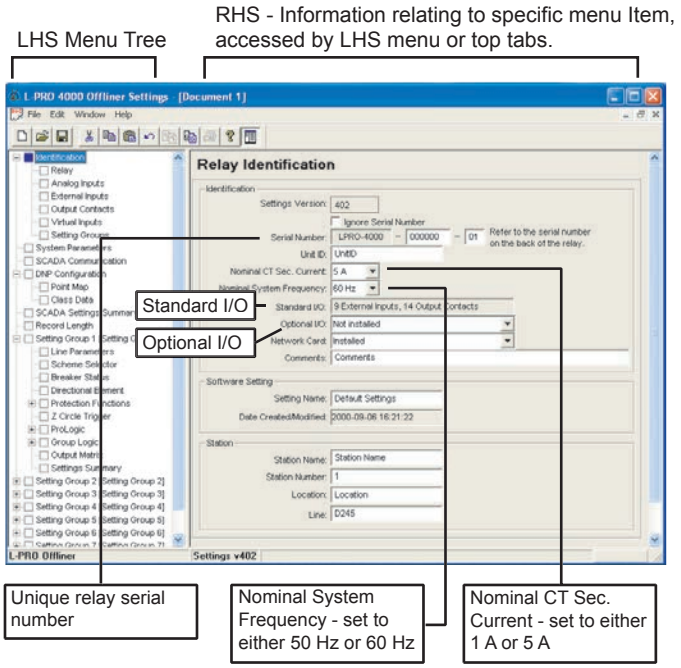

LHS Menu Tree
RHS - Information relating to specific menu Item, accessed by LHS menu or top tabs.
Standard I/O
Optional I/O
Unique relay serial number
Nominal System Frequency - set to either 50 Hz or 60 Hz
Nominal CT Sec. Current - set to either 1 A or 5 A

Figure 6.5: Relay Identification

In the LHS Menu Tree there are a series of menu headings that may have sub menus associated with them. Clicking on an item in the left hand side tree view will display its corresponding menu in the RHS view. Similarly, the user can use the arrow keys to scroll through the menu tree.

The serial number of the relay must match the one in the setting file, or the setting will be rejected by the relay. This feature ensures that the correct setting file is applied to the right relay.

The user can choose to ignore the serial number enforcement in the identification screen. The relay only checks for proper relay type and setting version if the ignore serial number has been chosen.

Identification

The first screen presents all the menu items in the left menu tree. Access the menu items by clicking the tabs at the top of the screen or the item on the left menu tree.

Table 6.3: Identification

Identification	
Settings Version	Indicates the settings version number, fixed.
Ignore Serial Number	Bypass serial number check, if enabled.
Serial Number	Available at back of each relay.
Unit ID	User-defined up to 20 characters.
Nominal CT Format	5 A or 1 A
Nominal System Frequency	60 Hz or 50 Hz
Standard I/O	Indicates standard I/O values, fixed.
Optional I/O	Not installed or 11 External Inputs, 7 Output Contacts.
Network Card	Installed or Not installed
Comments	User-defined up to 78 characters.
Setting Software	
Setting Name	User-defined up to 20 characters.
Date Created/Modified	Indicates the last time settings were entered.
Station	
Station Name	User-defined up to 20 characters.
Station Number	User-defined up to 20 characters.
Location	User-defined up to 20 characters.
Line	User-defined up to 20 characters.

Important Note

Nominal CT Secondary Current can be set to either 1 A or 5 A. Nominal System Frequency can be set to either 50 Hz or 60 Hz. Ensure setting selection matches that of target the relay.

The serial number of the relay must match the one in the setting file, or the setting will be rejected by the relay. This feature ensures that the correct setting file is applied to the right relay.

Choose to ignore the serial number enforcement in the identification screen by checking the *Ignore Serial Number* check box. The relay only checks for proper relay type and setting version if the ignore serial number has been chosen, requires relay firmware version 1.0 or greater.

Analog Inputs

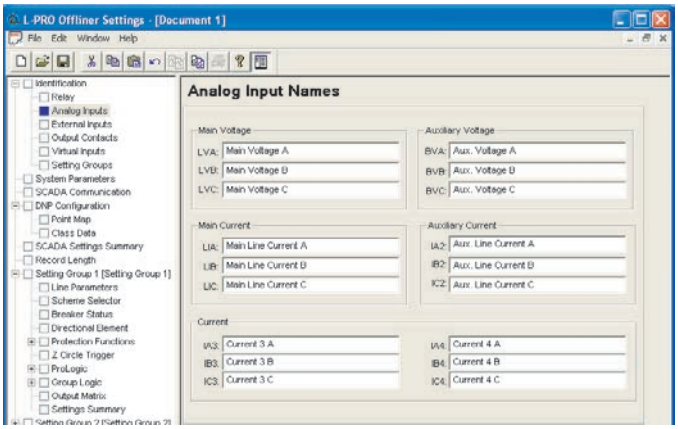


Figure 6.6: Analog Inputs

Analog Input Names screen identifies all the ac voltage and current inputs to the relay. These names appear in any fault disturbance records the relay produces.

Table 6.4: Analog Inputs	
Main Voltage	LVA, LVB, LVC
Main Current	LIA, LIB, LIC
Aux. Voltage	BVA, BVB, BVC
Aux. Current	IA2, IB2, IC2
Current	IA3, IB3, IC3, IA4, IB4, IC4

External Inputs

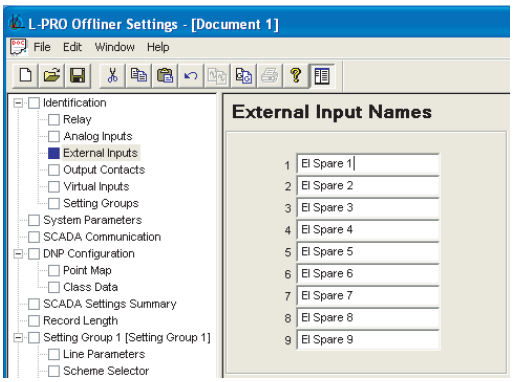


Figure 6.7: External Inputs

External Input Names screen allows the user to define meaningful names for 9 external digital inputs. Meaningful names may include terms such as T.T. (Transfer Trip) and P.T. (Permissive Trip).

Table 6.5: External Input Names	
1 to 20	User-defined

Output Contacts

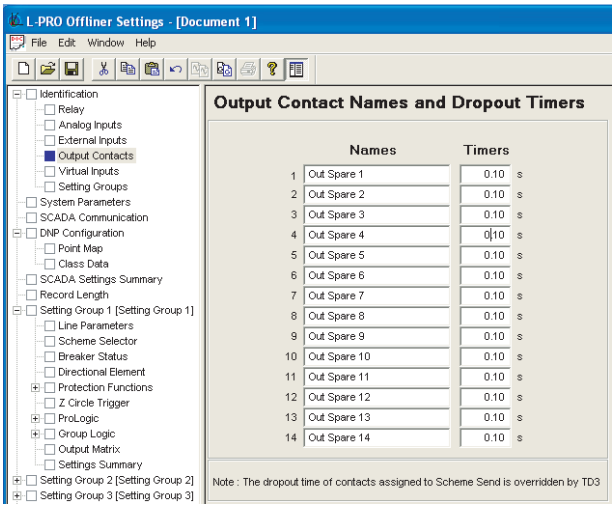


Figure 6.8: Output Contacts

The Output Contacts are also identified during the setting procedure using meaningful names. The dropout delay time settings are made here.

Table 6.6: Output Contact Names	
Outputs 1 to 21	User-defined
Dropout Timer	0.00 to 1.00 s

Virtual Inputs

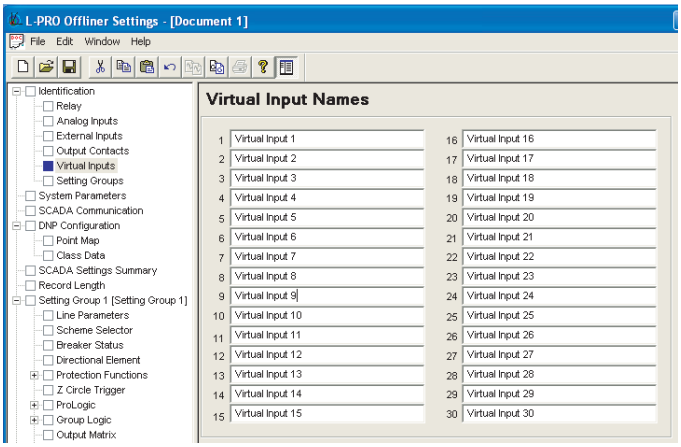


Figure 6.9: Virtual Inputs

Table 6.7: Virtual Inputs	
Virtual Inputs 1 to 30	User-defined

The relay can control its internal functions and connected devices both locally and remotely. Thirty general purpose logic points are accessible via DNP3 and the TUI. The 30 virtual inputs are individually controlled and include a set, reset and pulse function. The latch state is retained during setting changes and relay power down conditions. The 30 virtual inputs conform to DNP3 standards. Use the DNP3 functions such as SBO (select before operate), Direct Operate, or Direct Operate with no acknowledge to control virtual inputs.

Use virtual inputs to:

- control circuit breakers
- enable or disable reclosing
- enable or disable under-frequency load shedding

- change setting groups
- provide interlocking between local/remote supervisory control

Setting Groups

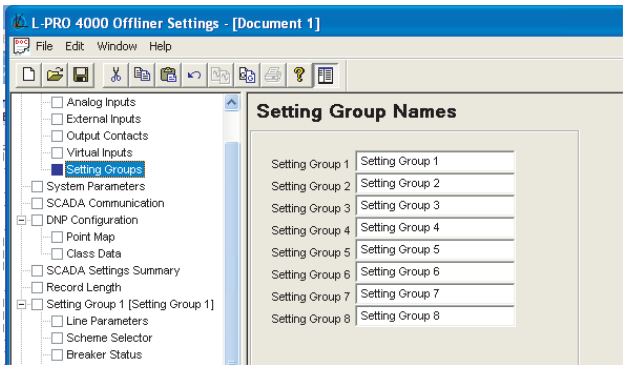


Figure 6.10: Setting Groups

Table 6.8: Setting Groups	
Setting Groups 1 to 8	User-defined

System Parameters

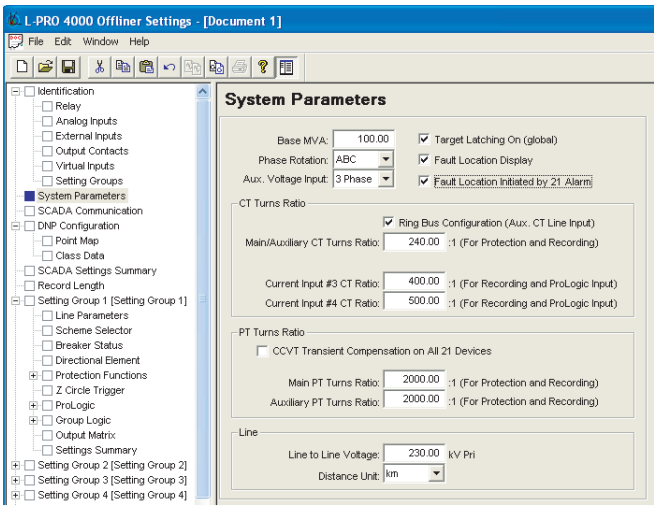


Figure 6.11: System Parameters

Table 6.9: System Parameters
System Parameters

Table 6.9: System Parameters	
Base MVA	1.00 to 2000.00 MVA (primary)
Target Latching On (global)	Enable/Disable
Phase Rotation	ABC or ACB
Fault Location Display	Enable/Disable
Aux Voltage Input	3-phase/1-phase
Fault Location Initiated by 21 Alarm	Enable/Disable
CT Turns Ratio	
Ring Bus Configuration (Aux. CT Line Input)	Enable/Disable
Main CT Turns Ratio	1.00 to 10000.00 (For protection and recording)
Auxiliary CT Turns Ratio	1.00 to 10000.00 (For protection and recording)
Current Input #3 CT Ratio	1.00 to 10000.00 (For Mutual compensation, Recording and ProLogic Input)
Current Input #4 CT Ratio	1.00 to 10000.00 (For Mutual compensation, Recording and ProLogic Input)
PT Turns Ratio	
CCVT Transient Compensation on All 21 Devices	Enable/Disable
Main PT Turns Ratio	1.00 to 20000.00 (For Protection and Recording)
Auxiliary PT Turns Ratio	1.00 to 20000.00 (For protection and recording)
Line	
Line to Line Voltage	1.00 to 2000.00 kV (Primary)
Distance Units	km or miles

Target Latching On

This option specifies whether the front Target LED is latched or not. Target Latching on means that the target LED remains on after a trip until it is reset through the front by Human Machine Interface (HMI). If the Target Latching is set off the target light comes on during a relay trip and will reset.

Base MVA

The base MVA is used for recording purposes.

CT Turns Ratio and PT Turns Ratio

The CT and PT ratios are specified for the monitoring of analog inputs. All CT and PT ratios are specified with a ratio relative to one. The line protection uses the main current and the main voltage to operate. When 2 sets of CTs (main and auxiliary) are used as line current input (e.g. ring bus application), the user must enable ring bus configuration to configure the relay. If enabled, the currents from the 2 sets of CTs are added to the relay to form the line current. For

cases where voltage for line protection is obtained from bus PTs, the bus PTs are connected to the main voltage inputs.

Auxiliary Voltage Input

If a single-phase source is used, it must be connected to the corresponding phase designation on the relay input. example: If only a B phase bus PT is available, it should be connected to the relay input B phase terminals. All un-used single-phase inputs must be grounded for proper operation.

SCADA Communication

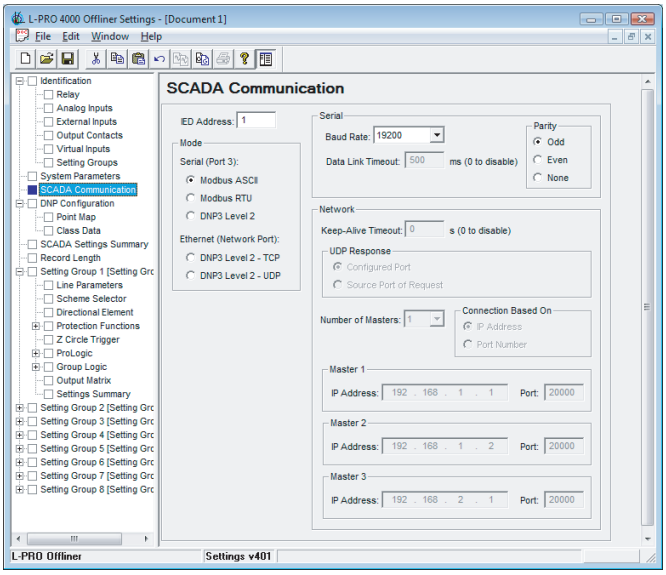


Figure 6.12: SCADA Communication

The relay has configurable SCADA communication parameters for both Serial and Ethernet (TCP and UDP). For DNP3 Level 2 (TCP) up to 3 independent Masters are supported.

DNP Configuration - Point Map

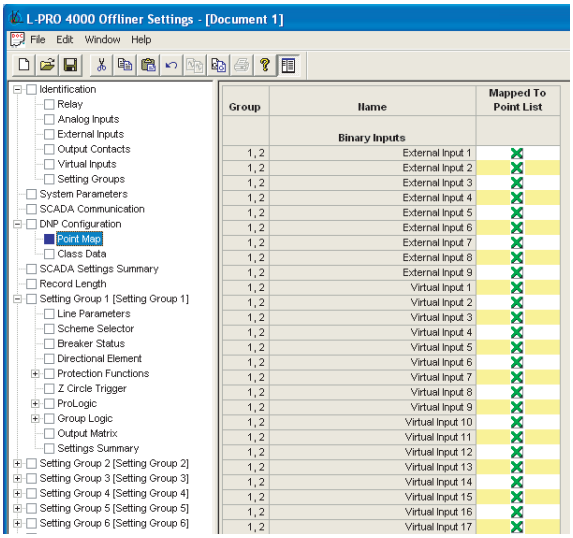


Figure 6.13: Point Map

The relay has configurable DNP point mapping. On the Point Map screen, any of the configurable points may be added or removed from the Point List by clicking (or using the cursor keys and space bar on the keyboard) on the associated check box. A green 'X' denotes that the item will be mapped to the Point List.

The list contains separate sections for Binary Inputs, Binary Outputs, and Analog Inputs. The list is scrollable by using the scroll control on the right hand side.

DNP Configuration - Class Data

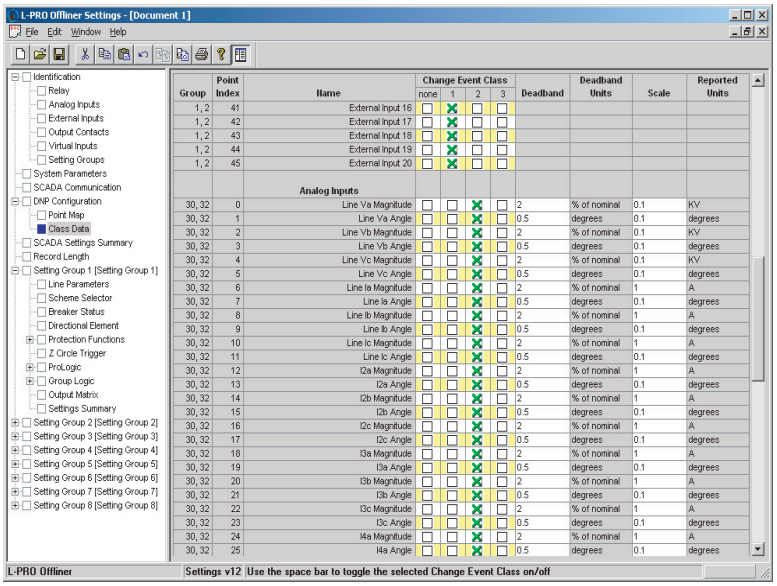

L-PRO Offliner Settings - [Document 1]
File Edit Window Help
Identification
Relay
Analog Inputs
External Inputs
Output Contacts
Virtual Inputs
Setting Groups
System Parameters
SCADA Communication
DNP Configuration
Point Map
Class Data
SCADA Settings Summary
Record Length
Setting Group 1 [Setting Group 1]
Line Parameters
Scheme Selector
Breaker Status
Directional Element
Protection Functions
Z Circle Trigger
ProLogic
Group Logic
Output Matrix
Settings Summary
Setting Group 2 [Setting Group 2]
Setting Group 3 [Setting Group 3]
Setting Group 4 [Setting Group 4]
Setting Group 5 [Setting Group 5]
Setting Group 6 [Setting Group 6]
Setting Group 7 [Setting Group 7]
Setting Group 8 [Setting Group 8]
Group
Point Index
Name
Change Event Class
none
1
2
3
Deadband
Deadband Units
Scale
Reported Units
1, 2 41 External Input 16
1, 2 42 External Input 17
1, 2 43 External Input 18
1, 2 44 External Input 19
1, 2 45 External Input 20
Analog Inputs
30, 32 0 Line Va Magnitude 2 % of nominal 0.1 KV
30, 32 1 Line Va Angle 0.5 degrees 0.1 degrees
30, 32 2 Line Vb Magnitude 2 % of nominal 0.1 KV
30, 32 3 Line Vb Angle 0.5 degrees 0.1 degrees
30, 32 4 Line Vc Magnitude 2 % of nominal 0.1 KV
30, 32 5 Line Vc Angle 0.5 degrees 0.1 degrees
30, 32 6 Line Ia Magnitude 2 % of nominal 1 A
30, 32 7 Line Ia Angle 0.5 degrees 0.1 degrees
30, 32 8 Line Ib Magnitude 2 % of nominal 1 A
30, 32 9 Line Ib Angle 0.5 degrees 0.1 degrees
30, 32 10 Line Ic Magnitude 2 % of nominal 1 A
30, 32 11 Line Ic Angle 0.5 degrees 0.1 degrees
30, 32 12 I2a Magnitude 2 % of nominal 1 A
30, 32 13 I2a Angle 0.5 degrees 0.1 degrees
30, 32 14 I2b Magnitude 2 % of nominal 1 A
30, 32 15 I2b Angle 0.5 degrees 0.1 degrees
30, 32 16 I2c Magnitude 2 % of nominal 1 A
30, 32 17 I2c Angle 0.5 degrees 0.1 degrees
30, 32 18 I3a Magnitude 2 % of nominal 1 A
30, 32 19 I3a Angle 0.5 degrees 0.1 degrees
30, 32 20 I3b Magnitude 2 % of nominal 1 A
30, 32 21 I3b Angle 0.5 degrees 0.1 degrees
30, 32 22 I3c Magnitude 2 % of nominal 1 A
30, 32 23 I3c Angle 0.5 degrees 0.1 degrees
30, 32 24 I4a Magnitude 2 % of nominal 1 A
30, 32 25 I4a Angle 0.5 degrees 0.1 degrees
L-PRO Offliner
Settings v12
Use the space bar to toggle the selected Change Event Class on/off

Figure 6.14: Class Data

Class data for each DNP point can be assigned on the Class Data screen. Only Points which were mapped in the Point Map screen will appear here. Sections for Binary Inputs and Analog Inputs appear here; Binary Outputs cannot be assigned a Class. The list is scrollable by using the scroll control on the right hand side.

In addition to assigning a Change Event Class to each mapped point, most Analog Inputs can also be assigned a Deadband and Scaling factor.

SCADA Settings Summary

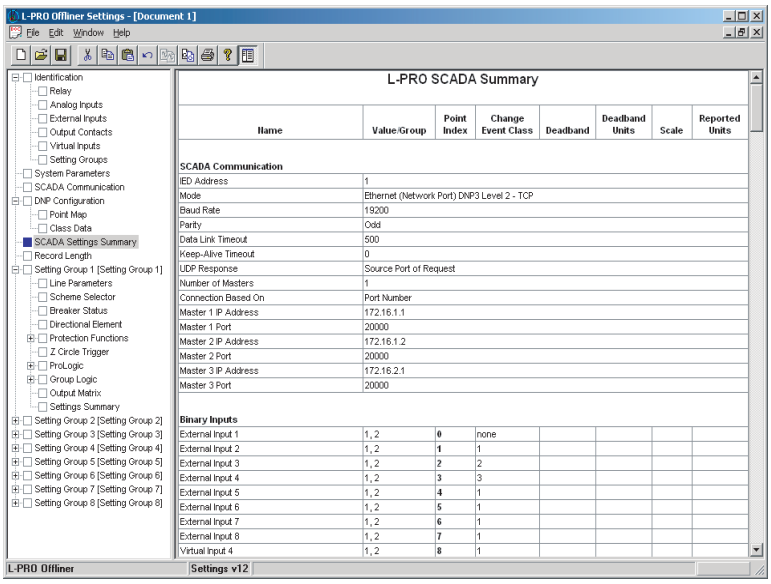

L-PRO Offliner Settings - [Document 1]
File Edit Window Help
Identification
Relay
Analog Inputs
External Inputs
Output Contacts
Virtual Inputs
Setting Groups
System Parameters
SCADA Communication
DNP Configuration
Point Map
Class Data
SCADA Settings Summary
Record Length
Setting Group 1 [Setting Group 1]
Line Parameters
Scheme Selector
Breaker Status
Directional Element
Protection Functions
Z Circle Trigger
ProLogic
Group Logic
Output Matrix
Settings Summary
Setting Group 2 [Setting Group 2]
Setting Group 3 [Setting Group 3]
Setting Group 4 [Setting Group 4]
Setting Group 5 [Setting Group 5]
Setting Group 6 [Setting Group 6]
Setting Group 7 [Setting Group 7]
Setting Group 8 [Setting Group 8]
L-PRO SCADA Summary
Name | Value/Group | Point Index | Change Event Class | Deadband | Deadband Units | Scale | Reported Units
SCADA Communication
IED Address | 1
Mode | Ethernet (Network Port) DNP3 Level 2 - TCP
Baud Rate | 19200
Parity | Odd
Data Link Timeout | 500
Keep-Alive Timeout | 0
UDP Response | Source Port of Request
Number of Masters | 1
Connection Based On | Port Number
Master 1 IP Address | 172.16.1.1
Master 1 Port | 20000
Master 2 IP Address | 172.16.1.2
Master 2 Port | 20000
Master 3 IP Address | 172.16.2.1
Master 3 Port | 20000
Binary Inputs
External Input 1 | 1, 2 | 0 | none
External Input 2 | 1, 2 | 1 | 1
External Input 3 | 1, 2 | 2 | 2
External Input 4 | 1, 2 | 3 | 3
External Input 5 | 1, 2 | 4 | 1
External Input 6 | 1, 2 | 5 | 1
External Input 7 | 1, 2 | 6 | 1
External Input 8 | 1, 2 | 7 | 1
Virtual Input 4 | 1, 2 | 8 | 1
L-PRO Offliner
Settings v12

Figure 6.15: SCADA Settings Summary

This screen provides a summary of the current SCADA settings as set in the working setting file. This includes SCADA Communication parameters and (if the SCADA mode is set to DNP) Binary Input, Binary Output, and Analog Input information including Deadband and Scaling factors.

This SCADA Summary screen is scrollable and can be printed.

Record Length

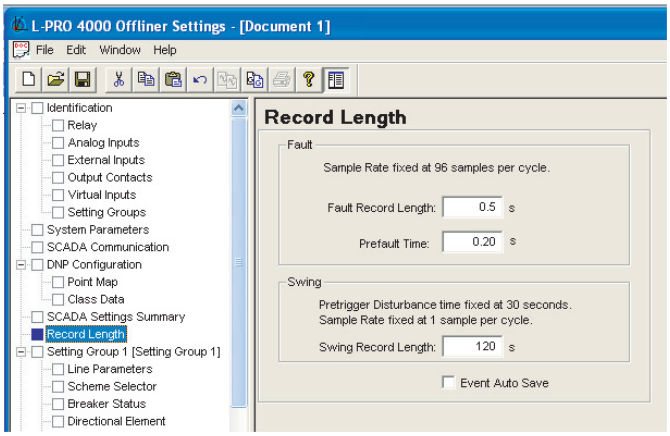


Figure 6.16: Record Length

Table 6.10: Record Length	
Fault	
Fault Record Length	0.2 to 10.0 seconds
Prefault Time	0.10 to 2.00 seconds
Swing	
Swing Record Length	60 to 120 seconds
Event Auto Save	Enable/Disable

The relay has recording and logging functions to analyze faults and dynamic swing, and to review the operation of the overall protection scheme.

This screen displays the record length for each of the two types of recordings provided: fault and swing. Pre-trigger times are configurable between 0.10 to 2.00 seconds for fault records and fixed at 30 seconds for swing records and are included as part of the record length.

Setting Groups

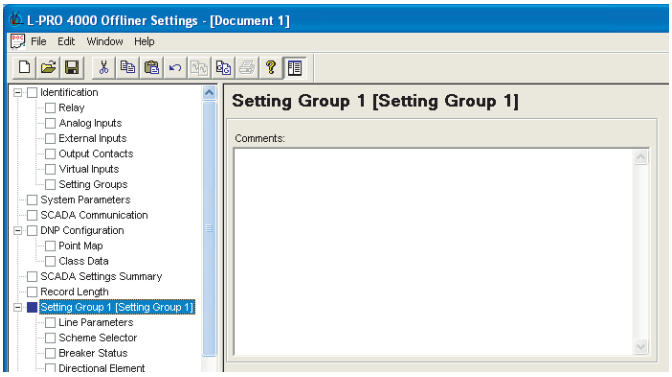


Figure 6.17: Setting Groups Comments

The relay has 8 setting groups (SG). The user can change all relay setting parameters except the physical connections such as input or output parameters in each setting group. Use any one of the 16 available Group Logic Statements per setting group to perform Setting Group changes. The Group Logic statements are similar to the ProLogic statements with the following exceptions, the sole function is to activate one of the 8 setting groups and the processing is in a slower half second cycle. Group Logic inputs statements can be driven from ProLogic or any external input or virtual input or from previous Group Logic statements. Each Group Logic statement includes 5 inputs (with Boolean statements), one latch state and one pickup delay timer. View the active setting group (ASG) from the Terminal Mode, from the front panel or from a record stored by the relay (the active setting group is stored with the record).

Line Parameters

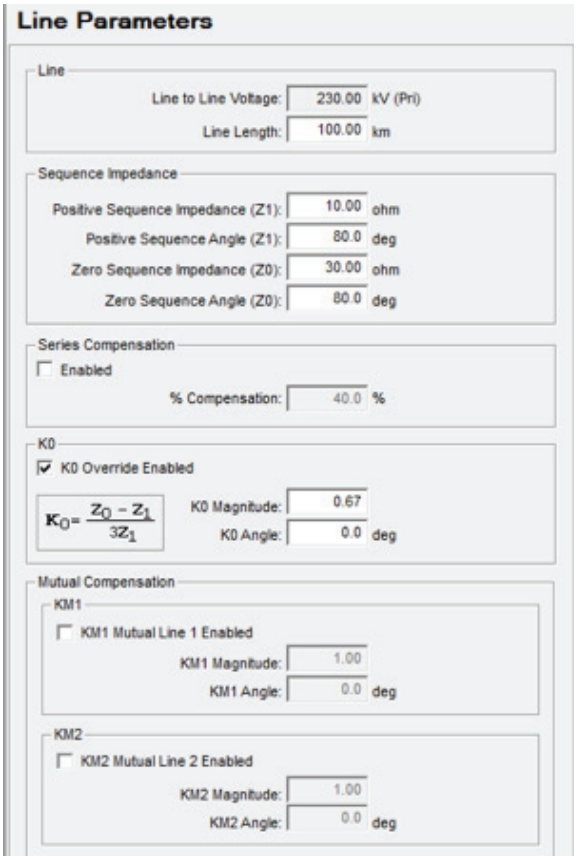


Figure 6.18: Line Parameters

Table 6.11: Line Parameters	
Line	
Line to Line voltage	1.00 to 2000.00 kV primary
Line Length (km/mile)	0.50 to 2000.00
Sequence Impedance	
Positive Sequence Impedance (Z1) (ohm secondary)	0.01 to 66.00 (5A) 0.05 to 330.00 (1A)
Positive Sequence Angle (Z1) (deg)	5.0 to 89.0
Zero Sequence Impedance (Z0) (ohm)	0.01 to 300.00 (5A) 0.05 to 1500.00 (1A)
Zero Sequence Angle (Z0) (deg)	5.0 to 89.0
Series Compensation	
Series compensation enabled	Enable Disable

Table 6.11: Line Parameters	
% compensation	0.0 to 70.0
K0	
K0 Override	Enable/Disable
K0 Magnitude	0.00 to 10.00
K0 Angle (deg)	-180.0 to 180.0
Mutual Compensation	
KM1	
KM1 Mutual Line 1	Enable/Disable
KM1 Magnitude	0.10 to 2.00
KM1 Angle (deg)	-25.0 to 25.0
KM2	
KM2 Mutual Line 2	Enable/Disable
KM2 Magnitude	0.10 to 2.00
KM2 Angle (deg)	-25.0 to 25.0

Line Parameter Settings permit a parameter entry related to the line voltage, CT ratio, PT ratio, line length, line secondary positive and zero sequence impedance.

The K_0 factor used is a default factor based on the line parameters ($K_0 = [Z_0 - Z_1] / 3Z_1$). The user can specify by selecting *K_0 Override Enable*.

Scheme Selector

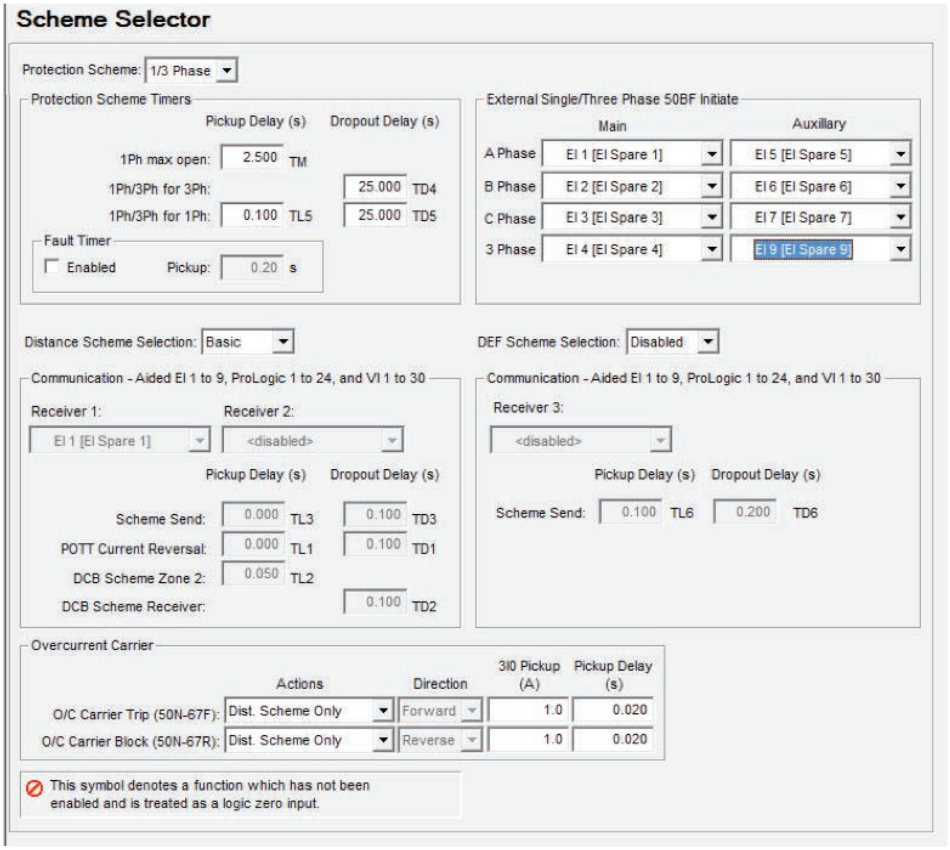

Scheme Selector
Protection Scheme: 1/3 Phase
Protection Scheme Timers
Pickup Delay (s)
Dropout Delay (s)
1Ph max open: 2.500 TM
1Ph/3Ph for 3Ph: 25.000 TD4
1Ph/3Ph for 1Ph: 0.100 TL5 25.000 TD5
Fault Timer
Enabled
Pickup: 0.20 s
External Single/Three Phase 50BF Initiate
Main
Auxillary
A Phase EI 1 [EI Spare 1] EI 5 [EI Spare 5]
B Phase EI 2 [EI Spare 2] EI 6 [EI Spare 6]
C Phase EI 3 [EI Spare 3] EI 7 [EI Spare 7]
3 Phase EI 4 [EI Spare 4] EI 9 [EI Spare 9]
Distance Scheme Selection: Basic
DEF Scheme Selection: Disabled
Communication - Aided EI 1 to 9, ProLogic 1 to 24, and VI 1 to 30
Receiver 1:
Receiver 2:
EI 1 [EI Spare 1]
<disabled>
Pickup Delay (s)
Dropout Delay (s)
Scheme Send: 0.000 TL3 0.100 TD3
POTT Current Reversal: 0.000 TL1 0.100 TD1
DCB Scheme Zone 2: 0.050 TL2
DCB Scheme Receiver: 0.100 TD2
Communication - Aided EI 1 to 9, ProLogic 1 to 24, and VI 1 to 30
Receiver 3:
<disabled>
Pickup Delay (s)
Dropout Delay (s)
Scheme Send: 0.100 TL6 0.200 TD6
Overcurrent Carrier
Actions
Direction
3I0 Pickup (A)
Pickup Delay (s)
O/C Carrier Trip (50N-67F): Dist. Scheme Only Forward 1.0 0.020
O/C Carrier Block (50N-67R): Dist. Scheme Only Reverse 1.0 0.020
This symbol denotes a function which has not been enabled and is treated as a logic zero input.

Figure 6.19: Scheme Selector

Table 6.12: Scheme Selector	
Protection Scheme	1 Phase/3 Phase/1/3 Phase
1Ph Max Open Pickup Delay (TM) sec	0.100 to 5.000
1Ph/3Ph for 3Ph Dropout Delay (TD4) sec	0.100 to 999.000
1Ph/3Ph for 1Ph Pickup Delay (TL5) sec	0.100 to 5.000
1Ph/3Ph for 1Ph Dropout Delay (TD5) sec	0.100 to 999.000
Fault Timer	Enable/Disable
Pickup sec	0.05 to 10
Distance Scheme	
Communication Scheme Selection	Basic/POTT/PUTT/DCB
Communication Receiver1	EI 1 to EI20, PL1 to PL24, VI1 to VI30

Table 6.12: Scheme Selector	
Communication Receiver2	Disabled, EI 1 to EI20, PL1 to PL24, VI1 to VI30
Scheme Send Pickup Delay (TL3) sec	0.000 to 1.000
Scheme Send Dropout Delay (TD3) sec	0.000 to 1.000
POTT Current Reversal Pickup Delay (TL1) sec	0.000 to 0.500
POTT Current Reversal Dropout Delay (TD1) sec	0.000 to 0.500
DCB Scheme Zone 2 Pickup Delay (TL2) sec	0.005 to 0.500
DCB Scheme Receiver Dropout Delay (TD2) sec	0.000 to 0.500
DEF Scheme	
DEF Scheme Selection	Disable/Permissive/Blocking
Communication Receiver3	Disabled, EI 1 to EI20, PL1 to PL24
DEF Scheme Send Pickup Delay (TL6) sec	0.000 to 1.000
DEF Scheme Send Dropout Delay (TD6) sec	0.000 to 1.000
External Single Phase 50BF Initiate	
Main A Phase	Disabled, EI 1 to EI20, PL1 to PL24, VI1 to VI30
Main B Phase	Disabled, EI 1 to EI20, PL1 to PL24, VI1 to VI30
Main C Phase	Disabled, EI 1 to EI20, PL1 to PL24, VI1 to VI30
Main Three Phase	Disabled, EI 1 to EI20, PL1 to PL24, VI1 to VI30
Auxiliary A Phase	Disabled, EI 1 to EI20, PL1 to PL24, VI1 to VI30
Auxiliary B Phase	Disabled, EI 1 to EI20, PL1 to PL24, VI1 to VI30
Auxiliary C Phase	Disabled, EI 1 to EI20, PL1 to PL24, VI1 to VI30
AuxThree Phase	Disabled, EI 1 to EI20, PL1 to PL24, VI1 to VI30
50N-67F - Overcurrent Carrier Trip	
Action	DEF Scheme Only/DEF & Dist Scheme/DEF & ProLogic/DEF, Dist & ProLogic
Direction	Forward
3I0 Pickup A	0.2 to 50.0 (5A) 0.1 to 10.0 (1A)
Pickup Delay sec	0.005 to 99.990
50N-67R - Overcurrent Carrier Block	
Action	Dist Scheme Only/ ProLogic only/ Dist & Pro-Logic

Table 6.12: Scheme Selector	
Direction	Reverse
3I0 Pickup A	0.2 to 50.0 (5A) 0.1 to 10.0 (1A)
Pickup Delay sec	0.005 to 99.990

The relay supports a Basic (no communication), a Permissive Overreaching Transfer Tripping (POTT), a Permissive Under-reaching Transfer Tripping (PUTT) and a Directional Comparison Blocking Scheme (DCB).

Directional Element

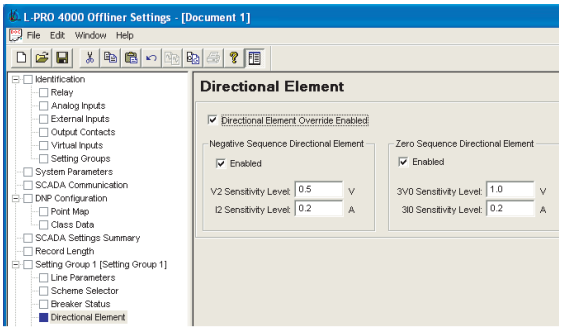


Figure 6.20: Directional Element

Table 6.13: Directional Element	
Directional Element Override	Enable/Disable
Negative Sequence Directional Element	Enable/Disable
V2 Sensitivity Level	0.5 to 5.0 Volts secondary
I2 Sensitivity Level	0.1 to 1.0 A secondary (5A) 0.02 to 0.20 A secondary (1A)
Zero Sequence Directional Element	Enable/Disable
3V0 Sensitivity Level	1.0 to 10.0 Volts secondary
3I0 Sensitivity Level	0.2 to 2.0 A secondary (5A) 0.04 to 0.40 A secondary (1A)

Protection Functions

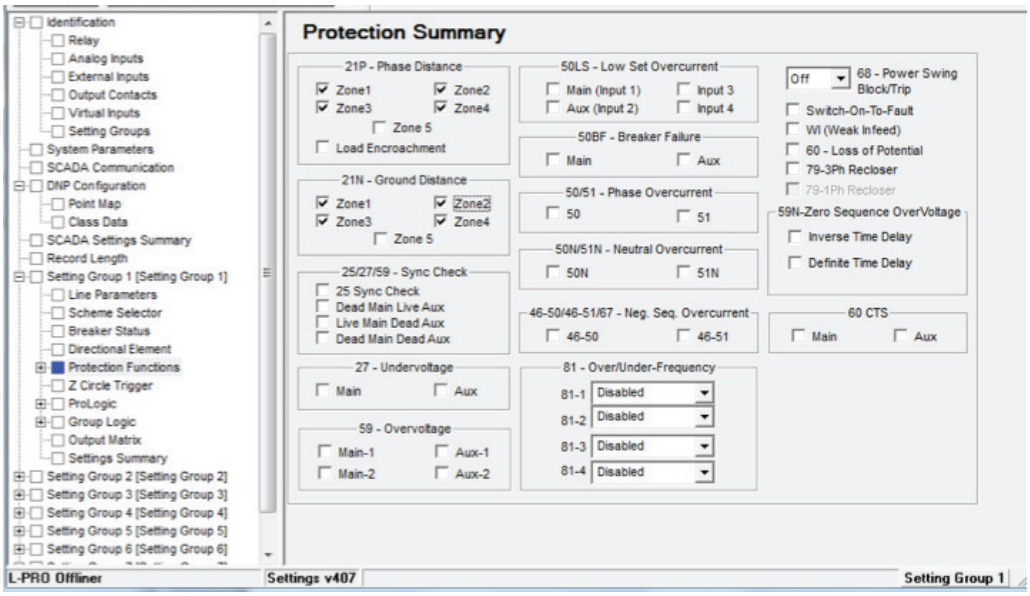


Figure 6.21: Protection Functions

For a detailed description see “Protection Functions and Specifications” on page 4-1

ProLogic

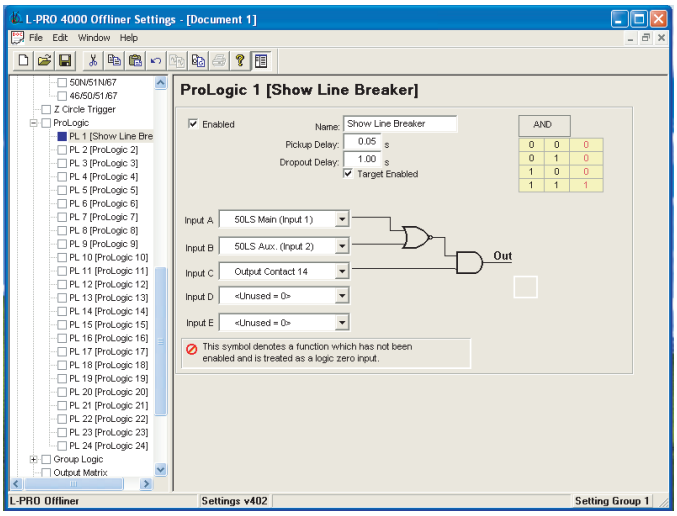

L-PRO 4000 Offliner Settings - [Document 1]
File Edit Window Help
ProLogic 1 [Show Line Breaker]
Enabled
Name: Show Line Breaker
Pickup Delay: 0.05 s
Dropout Delay: 1.00 s
Target Enabled
AND
Input A 50LS Main (Input 1)
Input B 50LS Aux. (Input 2)
Input C Output Contact 14
Input D <Unused = 0>
Input E <Unused = 0>
Out
This symbol denotes a function which has not been enabled and is treated as a logic zero input.
L-PRO Offliner
Settings v402
Setting Group 1

Figure 6.22: ProLogic

Apply ProLogic to multiple inputs to create an output based on qualified inputs. ProLogic enables up to 24 ProLogic control statements and programs those logics to output contacts. The user can name the function being created and set a pickup and dropout delay. Start with input A by selecting any of the

relay functions using the list for up to 5 possible inputs. Put these inputs into AND, NAND, OR, NOR, XOR, NXOR and LATCH logics by clicking on the gate. Invert the input by clicking on the input line.

The output of ProLogic 1 can be nested into ProLogic 2 and so forth. If described, the user can illuminate the front target LED on operation of this function by enabling this feature. The operation of the ProLogic statements are recorded in the events logs.

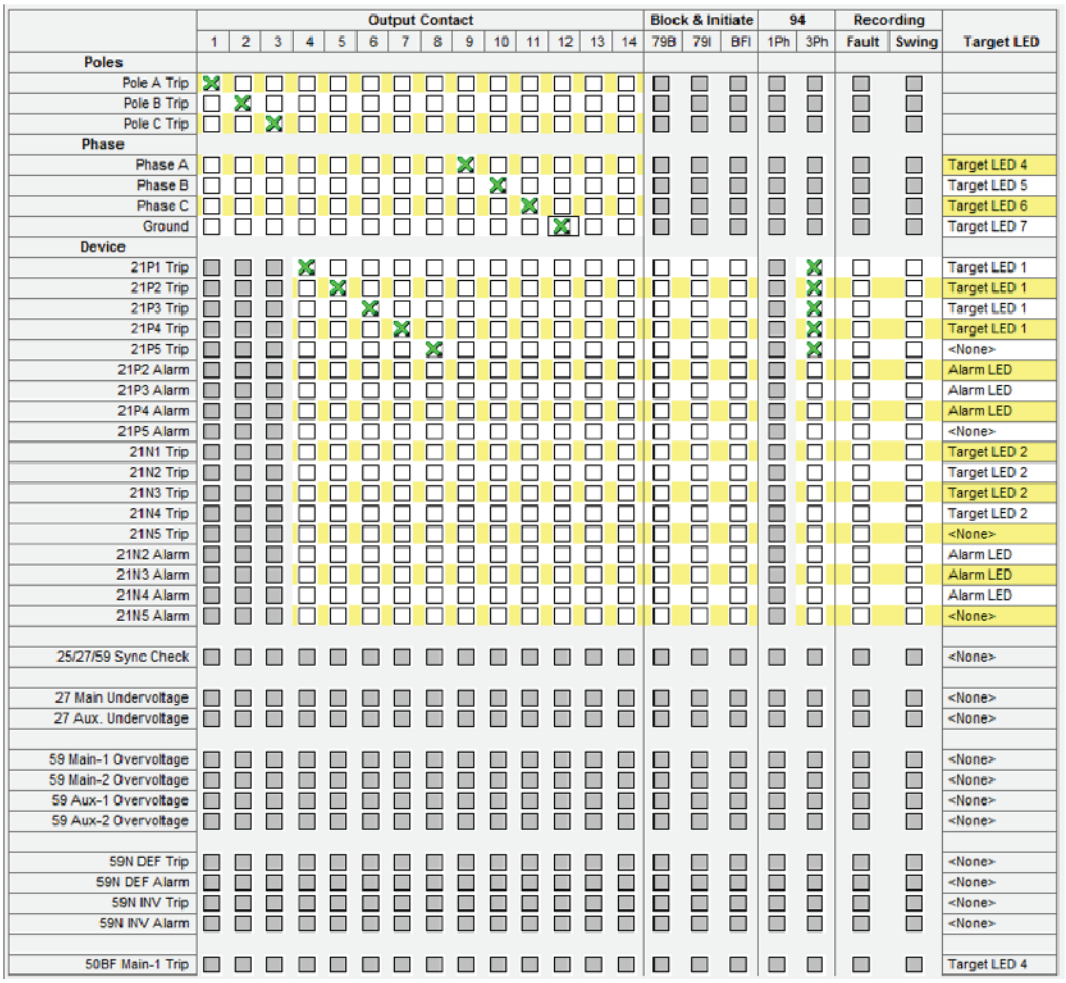
The above is an example of a ProLogic application where an output is produced if either of the line breakers is slow to open following a line fault.

In this example current through the main and aux line breaker is present as measured by the 50LS Main and the 50LS Aux functions after a protection line trip as by Output Contact 14 and after the 0.50 ms (3 cycles) ProLogic 1 pickup time delay.

Group Logic

The 16 Group Logic statements reside in a slower processing thread within the relay protection algorithms. The processing cycle happens once every half second (0.5 s). When using ProLogic statements the user must keep in mind that a latch or dropout timer should be used if the initiating condition does not last at least 0.5 seconds.

Output Matrix



	Output Contact														Block & Initiate			94		Recording		Target LED
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	79B	79I	BFI	1Ph	3Ph	Fault	Swing	
Poles																						
Pole A Trip	X																					
Pole B Trip		X																				
Pole C Trip			X																			
Phase																						
Phase A									X													Target LED 4
Phase B										X												Target LED 5
Phase C											X											Target LED 6
Ground												X										Target LED 7
Device																						
21P1 Trip				X															X			Target LED 1
21P2 Trip					X														X			Target LED 1
21P3 Trip						X													X			Target LED 1
21P4 Trip							X												X			Target LED 1
21P5 Trip								X											X			<None>
21P2 Alarm																						Alarm LED
21P3 Alarm																						Alarm LED
21P4 Alarm																						Alarm LED
21P5 Alarm																						<None>
21N1 Trip																						Target LED 2
21N2 Trip																						Target LED 2
21N3 Trip																						Target LED 2
21N4 Trip																						Target LED 2
21N5 Trip																						<None>
21N2 Alarm																						Alarm LED
21N3 Alarm																						Alarm LED
21N4 Alarm																						Alarm LED
21N5 Alarm																						<None>
25/27/59 Sync Check																						<None>
27 Main Undervoltage																						<None>
27 Aux. Undervoltage																						<None>
59 Main-1 Overvoltage																						<None>
59 Main-2 Overvoltage																						<None>
59 Aux-1 Overvoltage																						<None>
59 Aux-2 Overvoltage																						<None>
59N DEF Trip																						<None>
59N DEF Alarm																						<None>
59N INV Trip																						<None>
59N INV Alarm																						<None>
50BF Main-1 Trip																						Target LED 4

Figure 6.23: Output Matrix

The output contact matrix determines which function initiates which output relay. All output relays have an individual user-selectable stretch time, except those outputs identified as communication initiation outputs. They can have their time delay characteristics changed. Functions also initiate recording as required.

> For a particular function to operate correctly, it must be enabled and must also have its logic output assigned to at least one output contact if it is involved in a tripping function.

Print the entire output matrix by selecting Print under the File menu. This printout is produced on 2 pages.

Settings Summary

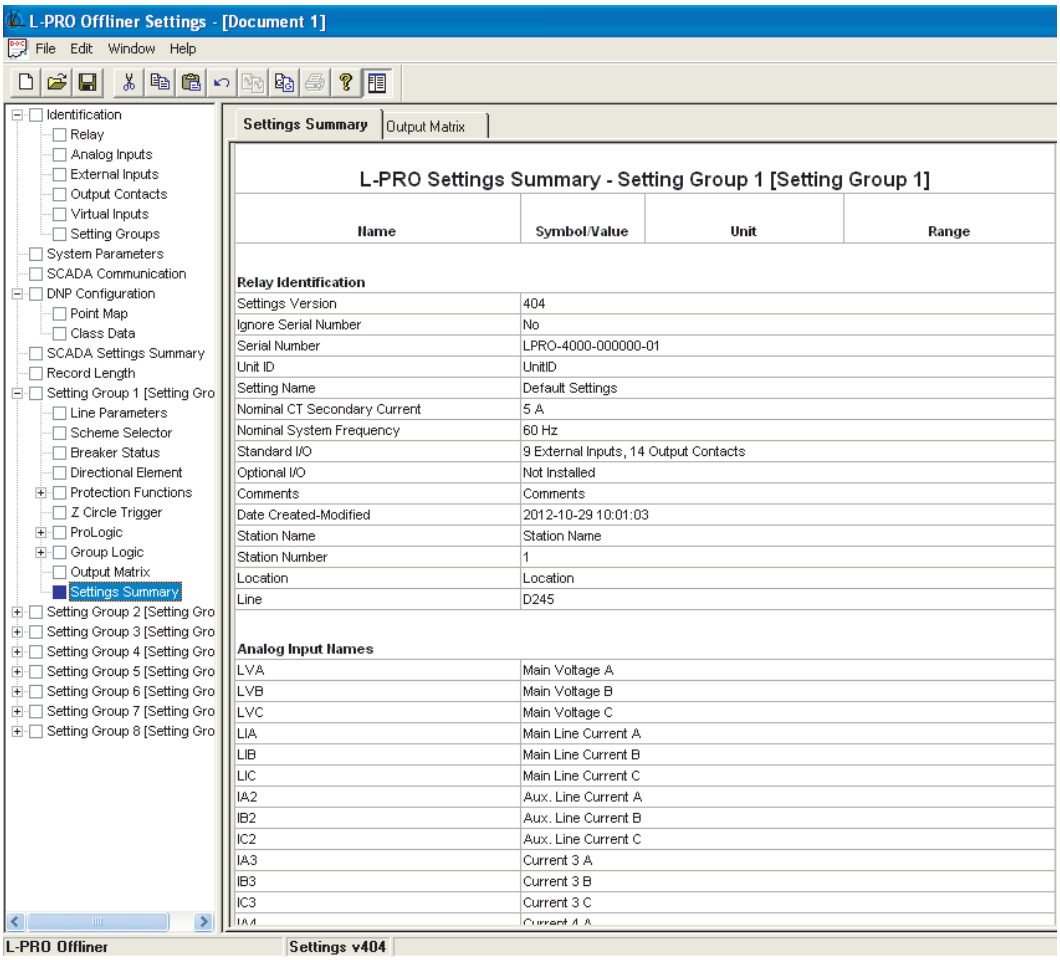


Figure 6.24: Settings Summary

Select *Settings Summary* to view and print the relay settings in text form, for details see “IED Settings and Ranges” in Appendix B.

6.7 Settings From a Record

The settings on the relay at the time of a recording are included in every record and can be viewed through the RecordBase View analysis software. While viewing a recording in RecordBase View, select the *View Setting* button to display the settings. RecordBase View will automatically launch L-PRO Offliner to display the settings in summary form.

If the record contains Setting Groups, the Offliner displays all Setting Groups in the summary. Bold text in the tree view indicates an active Setting Group (the Setting Group used at the time the record was captured). The setting summary is read-only. To edit the setting file associated with the summary, the user must use *File/Save As* to save the summary to a file. Then close the summary screen and open the setting file for editing.

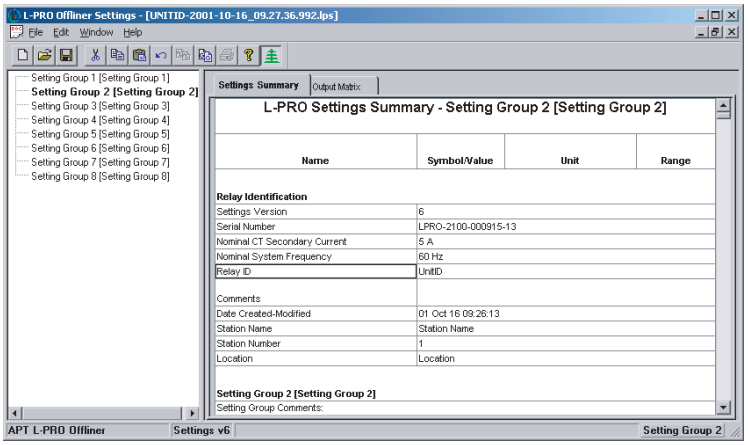


Figure 6.25: View Setting Summary in RecordBase View

7 Acceptance/Protection Function Test Guide

7.1 Introduction

The acceptance test section is a guide for testing any and all protection elements in the relay. These tests should be performed upon first delivery of the relay, prior to applying in-service settings. Once in-service settings are applied, ERLPhase recommends that the user test enabled functions to ensure the designed application is fulfilled.

This section deals with the Acceptance Testing and the L-PRO Acceptance Test Procedure.

First, the acceptance testing describes the test equipment requirements, calibration methods, testing the external inputs and testing the output relay contacts.

Next, a step-by-step test procedure for testing all the relay devices is outlined.

7.2 Acceptance Testing

ERLPhase relays are fully tested before leaving the factory. A visual inspection of the relay and its packaging is recommended on receipt to ensure the relay was not damaged during shipping.

> The electronics in the relay contain static sensitive devices and are not user-serviceable. If the front of the relay is opened for any reason exposing the electronics, take extreme care to ensure that the user and the relay are solidly grounded.

Generally an analog metering check, as well as testing the I/O (External Inputs and Output Contacts) is sufficient to ensure the functionality of the relay. Further tests can be performed on delivery and acceptance of the purchaser's option according to the published relay specifications in "IED Settings and Ranges" in Appendix B.

Test Equipment Requirements

- 3 ac voltage sources (variable frequency capability)
- 3 ac current sources
- 1 ohmmeter
- 1 - 125 Vdc test supply

Set nominal CT secondary current to either 5 A or 1 A, and nominal system frequency to either 60 Hz or 50 Hz. This example uses 5 A/ 60 Hz.

Calibration

The relay is calibrated before it leaves the factory; but if component changes are made within the relay, the user may need to do a re-calibration.

Before beginning a new calibration, establish the accuracy of the equipment being used.

To perform a calibration, the user must be logged into the relay using Relay Control Panel at the Service access level to the front USB Port. Proceed to the *Utilities>Analog Input Calibrate*. The *Calibrate* menu leads the user through every analog input and prompts the user to apply the appropriate quantity.

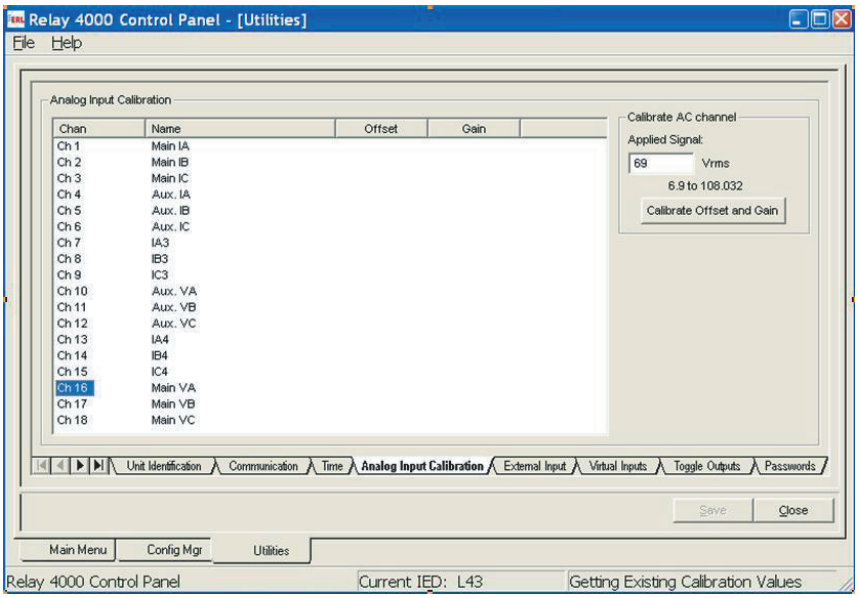


Figure 7.1: Enter actual applied signal level

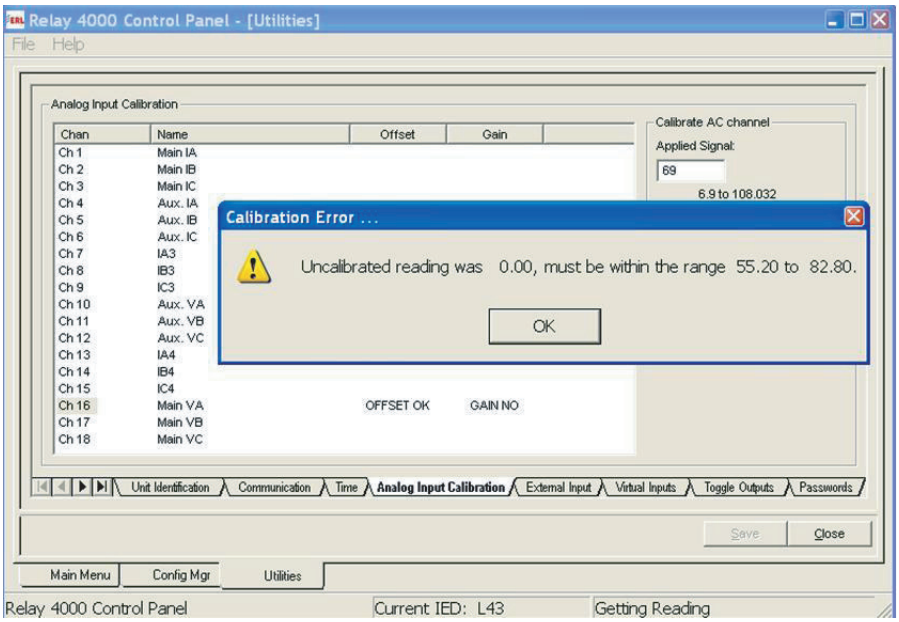


Figure 7.2: Calibration error - out of range

For example, when selecting channel 16 to calibrate Main VA, the Applied Signal check box will indicate the desired calibration of the relay. If a 69 V phase-to-neutral quantity is applied to the back VA terminals, 69.0 V would be indicated as the desired calibration. If a 69 V phase-to-neutral quantity is applied to the to the back VA terminals, 69.0 V would be indicated as the desired calibration.

In a similar way, the user needs to go through all 18 ac analog quantities and provide the information about the injected calibration quantities. The user must have a test source to perform this function. Only the magnitude of the analog input requires calibration, not the angle.

When an analog input channel is calibrated, verify the quantity measured by selecting the Metering menu and the Analog Quantity submenu. VA of the ac voltage input is used as a reference quantity by the relay. Therefore, if it is absent, there is not a locked, valid relationship among all of the analog quantities.

Testing the External Inputs

To test the external inputs connect the relay using Relay Control Panel, *Metering>External.* This screen displays the status of the Input and Output Contacts. Placing a voltage of 125 $Vdc_{nominal}$, (150 $V_{maximum}$), to each of the external inputs in turn causes the input to change from Low to High status. These inputs are polarity sensitive and this screen has a 0.5 second update rate.

Testing the Output Relay Contacts

Test the output relays to verify their integrity using the *Utilities>Toggle Outputs*. The output contacts are toggled from open to closed by pressing the *Closed* button. Verify the output contact status using an ohmmeter. When exiting this sub-menu, each contact status reverts to the open position.

7.3 L-PRO Acceptance Test Procedure Outline

Devices to Test

- 60 AC Loss of Potential
- 21P Phase-to-Phase Impedance
- 21N Phase-to-Neutral Impedance
- Load Encroachment
- Weak Infeed
- Switch-On-To-Fault
- 68 Power Swing
- 27 Undervoltage
- 59 Overvoltage
- 50N/51N Neutral Overcurrent
- 50/51 Phase Overcurrent
- 46-50/46-51 Negative Sequence Overcurrent
- 50LS Low Set Definite Time Overcurrent
- 50BF Breaker Fail
- Example of Inputs 3 and 4 being used for Breaker Fail
- 81 Over/Under/Rate of Change of Frequency
- 25C Sync Check
- 79 Recloser
- 79-1-3 single pole trip device number

Download Acceptance Test File

1. Browse to find the following Offliner Setting file "LPROaccTestsetting60hz" in C:\Program Files\ERLPhase\LPRO Offliner Settings\.
2. Double-click the *Setting* file to open. Enter the serial number of the relay being tested or check *Ignore Serial Number* checkbox.
3. Select *File* on the menu bar, then select *Convert to Newer* under its submenu, select *version 404*.

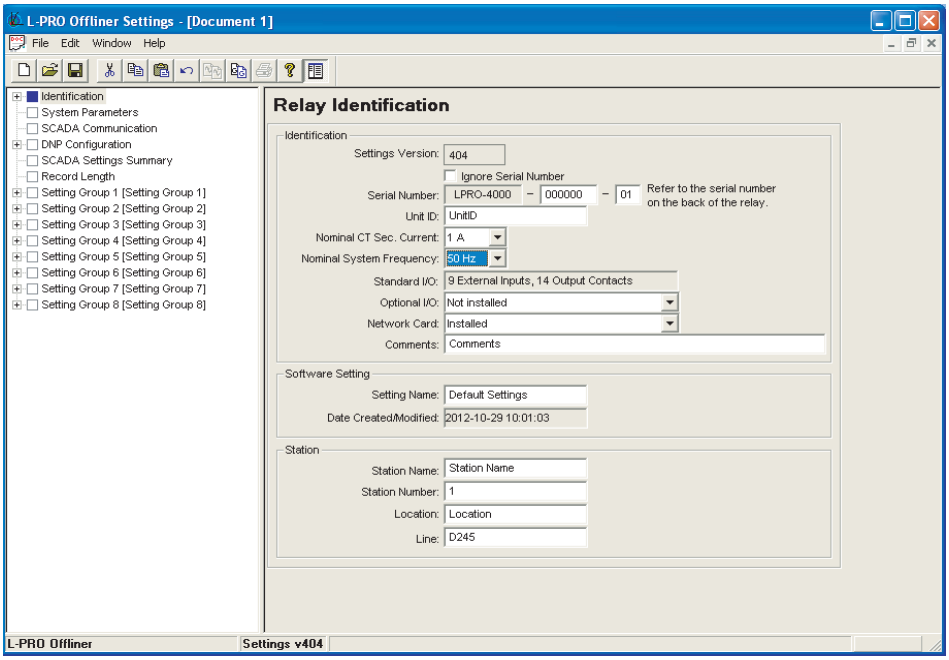


Figure 7.3: Identification Serial Number Screen

4. Save the file.
5. Connect to the relay in Service or Change mode via the relay front port (Port 150) using the Relay Control Panel.
6. From the Main Menu double click on *Configuration.*
7. From the Configuration submenu select *Import*.
8. Browse to the converted acceptance test file and click on *Open.*
9. Select the file under Saved Settings list and click on the *Load to IED* button on the right.

About the Acceptance Test Setting File

The acceptance test setting file provided is not necessarily configured to a provide a realistic setting example. Its configuration is intended to demonstrate simple test methods for each relay element. Tests are organized to prevent interference of one protection element on the next within the relay for ease of testing without using multiple setting files and minimizing the number of test connection changes. All contacts in the relay will be tested if all elements in this procedure are tested as written.

Testing all the elements is accommodated by using of the relay Setting Groups (3 groups are used).

Setting Group 1 tests elements: 21P, 21N, 68, 60, Switch-On-To-Fault, Weak Infeed

Setting Group 2 tests elements: 46-50/46-51, 50/51, 50N/51N, 27, 59, 50LS, 50BF

Setting Group 3 tests elements: 25/27/59 (Sync Check), 79, 81

The file demonstrates all types of impedance characteristics available in the relay: circle, tomato, lens, Quadrilateral.

Virtual Inputs are used to perform some input functions and demonstrate their use.

In addition to, or exclusive of these tests, the user may wish to perform dynamic simulation tests on the relay to verify the relay operates as per protection scheme design using the settings that are applied for the particular line on which the relay will be installed.

Impedance Characteristics Available in L-PRO (Mho and Quadrilateral)

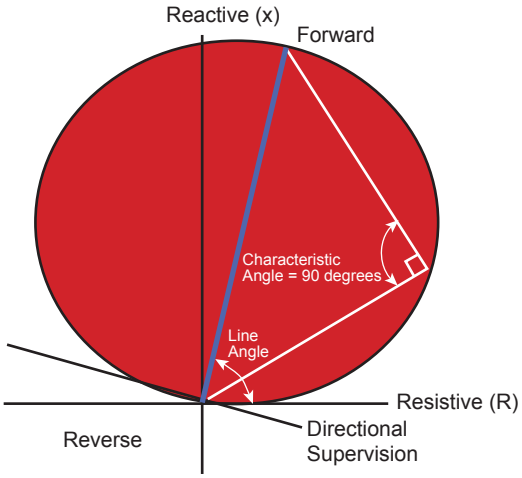


Figure 7.4: MHO Circle (Characteristic Angle = 90°) Available for 21P and 21N

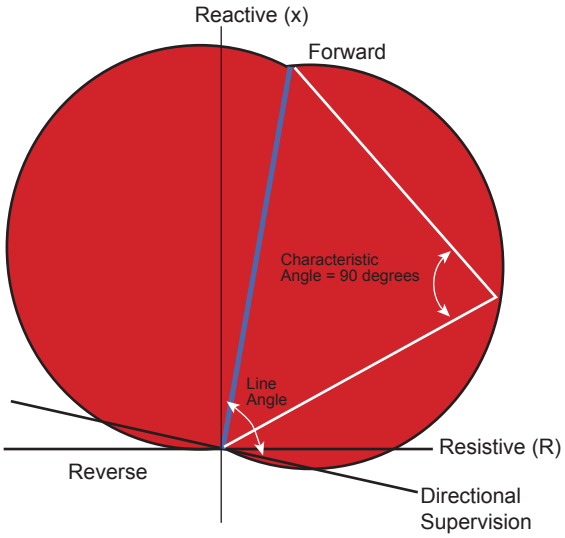


Figure 7.5: MHO Tomato (Characteristic Angle < 90°) Available for 21P and 21N

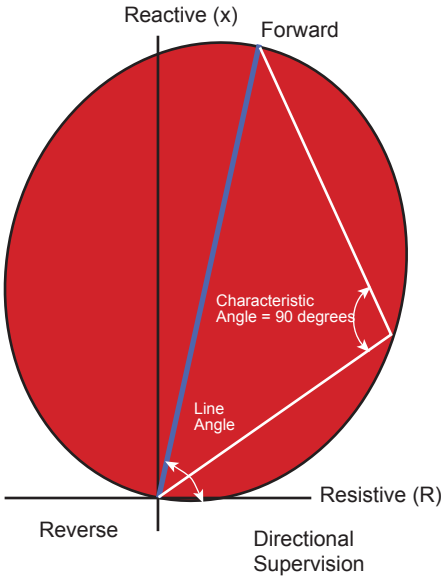


Figure 7.6: MHO Lens (Characteristic Angle > 90°) Available for 21P and 21N

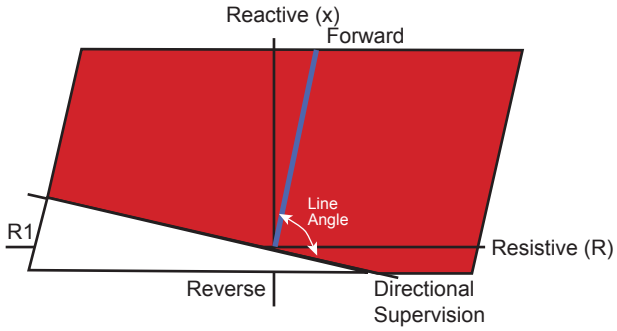


Figure 7.7: Quadrilateral Available for 21P and 21N Only

Basic Testing Calculations

$$\text{Nominal primary voltage} = \quad 230kV \tag{1}$$

$$\text{Nominal secondary phase-to-phase voltage} = \quad \frac{kV}{PTRatio} = \frac{230kV}{2000} = 115V \tag{2}$$

$$\text{Nominal secondary phase-to-neutral voltage} = \quad \frac{115V}{\sqrt{3}} = 66.4V \tag{3}$$

where

kV - Nominal Primary Voltage

$PT\ Ratio$ - Potential Transformer Ratio

Zero Sequence Impedance calculations for phase-to-ground impedance element tests (using secondary Positive and Zero Sequence Line Impedances):

$$Z_1 = 5.9\Omega\angle 80° = (1.03 + j5.81) \tag{4}$$

$$Z_0 = 16.0\Omega\angle 74° = (4.41 + j15.38) \tag{5}$$

$$K_0 = \frac{Z_0 - Z_1}{3 \times Z_1}$$
$$= \frac{[(4.41 - 1.03) + (j15.38 - j5.81)]}{3 \times 5.9\angle 80°}$$
$$= \frac{3.38 + j9.57}{17.7\angle 80°} = \frac{10.15\angle 70.52°}{17.7\angle 80°} = (0.57\angle -9.5) \quad (6)$$

where

Z_1 - Positive Sequence Impedance

Z_2 - Negative Sequence Impedance

K_0 - Factor

The multiplier used to compensate phase-to-ground impedances:

$$1 + K_0 = (1 + 0.57\angle -9.5°)$$
$$= (1 + 0.562 - j0.094)$$
$$= (1.562 - j0.094) = 1.569\angle -3.5° \quad (7)$$

21N Reach Settings

Zone 1 Reach: Mho 4.72 Ω

Zone 2 Reach: Quadrilateral X: 7.38 Ω, R: 6.00 Ω

Zone 3 Reach: Mho Forward 17.7 Ω, Reverse 0.50 Ω

Zone 4 Reach: Mho Forward 0.00 Ω, Reverse 4.72 Ω

Compensated 21N1 setting 4.72 Ω (Zone 1 phase-to-ground compensated Mho impedance):

$$4.72\Omega\angle 80° \times 1.569\angle -3.5° = 7.40\Omega\angle 76.5° \quad (8)$$

Compensated 21N2 Setting 7.38 Ω (Zone 2 phase-to-ground compensated Quadrilateral impedance):

Reactive: $7.38\Omega\angle 80° \times 1.569\angle -3.5° = 11.58\Omega\angle 76.5°$ (9)

Resistive: $6.0\Omega\angle 0° \times 1.569\angle -3.5° = 9.41\Omega\angle -3.5°$ (10)

The pure resistive component $9.41\Omega \times \cos(-3.5°) = 9.39\Omega\angle 0°$ (11)

Compensated 21N3 (Zone 3 Phase-to-ground compensated impedance):

Forward: $17.70\Omega\angle 80° \times 1.569\angle -3.5° = 27.76\Omega\angle 76.5°$ (13)

Reverse: $0.50\Omega\angle -100° \times 1.569\angle -3.5 = 0.78\Omega\angle -103.5°$ (14)

Compensated 21N4 (Zone 4 phase-to-ground compensated impedance)

Forward: 0 (must be 0 for POTT Scheme) (15)

Reverse: $4.72\Omega\angle -100° \times 1.569\angle -3.5° = 7.40\Omega\angle -103.5°$ (16)

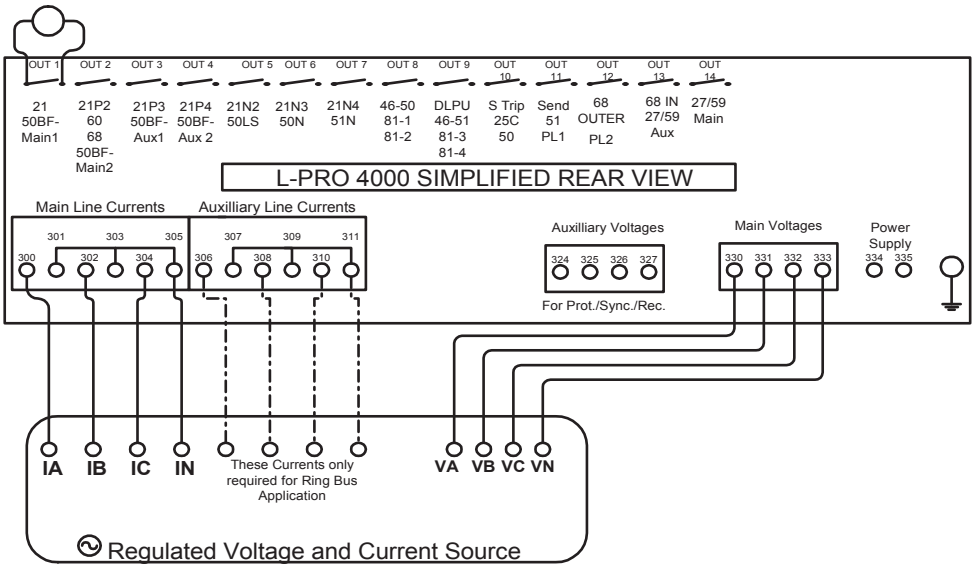


Figure 7.8: Suggested Test Connections for Acceptance Tests

Where each test specifies Metering/Protection, view the following screen under *Metering>Protection in* Relay Control Panel.

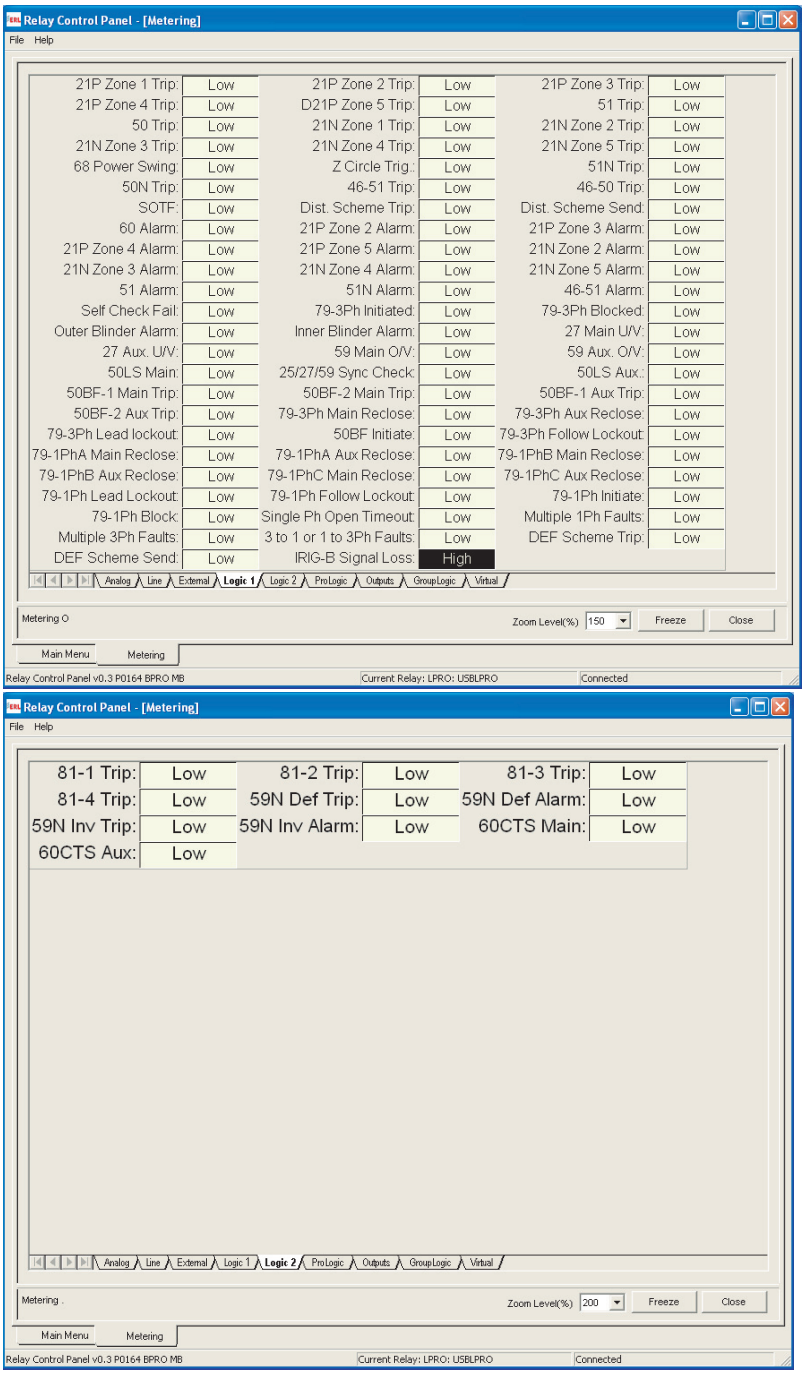


Figure 7.9: Protection Functions Metering Screens

60 Loss of Potential (LOP) Test

Settings

- Voltage = 0.75 per unit phase-to-neutral fixed (In this case minimum operate = 0.75 per unit = 0.75 * $V_{nominal}$ = 0.75 * 66.4 V = 49.8 V)
- I_1 Blocking = 10.0 A (positive sequence current that blocks LOP if exceeded)
- 3_{I0} Blocking = 1.0 A (zero sequence current that blocks LOP if exceeded)
- Neg. Seq. Monitoring = disabled

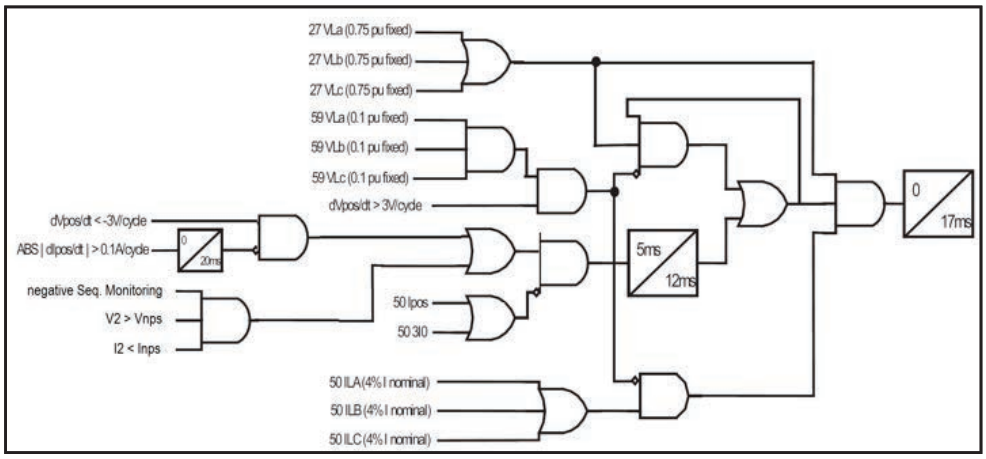


Figure 7.10: Loss of Potential Logic (60)

60 Test Procedure:

1. In Relay Control Panel access relay *Metering>Logic>Protection*.
   Monitor: 60 Alarm
2. Apply balanced 3-phase nominal voltages (66.4 V) to the relay terminals:
   Ph A: 330, 66.4 V ∠0°
   Ph B: 331, 66.4 V ∠-120°
   Ph C: 332, 66.4 V ∠+120°
   Ph N: 333
3. Connect 3-phase current sources (0.5 A) to the relay terminals (must be greater than 0.2 A (4% $I_{nominal}$) to enable due to low set supervision, for details see Figure 7.10: Loss of Potential Logic (60) on page 7-12).
   Ph A: 300 – 301, 0.5 A ∠0°
   Ph B: 302 – 303, 0.5 A ∠-120°
   Ph C: 304 – 305, 0.5 A ∠+120°
   Observe: 60 Alarm = Low
4. Instantaneously reduce single-phase voltage to 48 V or less.
   60 Alarm = High
   Contact 2 Closed

Testing the LOP I1 Supervision:

1. Restore 3-phase voltages to 66.4 V.
   Observe 60 Alarm = Low
   Contact 2 = Open
2. Increase balanced 3-phase currents to 10.1 A per phase.
3. Reduce single-phase voltage to 0.
   Observe 60 Alarm remains low
   Observe Contact 2 remains open
4. Reduce currents to 0.

Testing the LOP 3_{IO} Supervision

1. Restore 3-phase voltages to 66.4 V.
   Observe 60 Alarm = Low
   Contact 2 = Open
2. Increase any single-phase current to 1.1 A.
3. Reduce single-phase voltage to 0.
   Observe 60 Alarm remains low.
   Observe Contact 2 remains open.
4. Reduce all sources to 0.

Testing Negative Seq. Supervision

1. Instantaneously, apply following signals
   Voltages:
   Ph A: 330, 66.4 V < 0°
   Ph B: 331, 0 V
   Ph C: 332, 0 V
   Ph N:333
   Currents:
   Ph A: 300 – 301, 0.5A < 0°
   Ph A: 302 – 303, 0.5A < -120°
   Ph A: 304 – 305, 0.5A < +120°
   Observe 60 Alarm = Low
2. Reduce all sources to 0.
3. Change settings as given below.
   Enable Neg. Seq. Monitoring
   Vnps = 10.0 V
   Inps = 0.5 A
4. Repeat, step 1.
   Observe 60 Alarm = High
5. Reduce all sources to 0.

End of 60 test.

21P1 Phase Distance Test

(Zone 1 Single-Phase Under Impedance Test tested as 3-phase fault)

Settings

- Positive Sequence Secondary Line Impedance (100% of line)= 5.9 Ω
- Positive Sequence Line Angle = 80
- 21P1 = 4.72 Ω (Maximum Reach = 80% of line at maximum torque angle of 80°)
- Time Delay = 0 (expect 1.3 cycles, 22 ms or less)
- Delta Current Supervision = 7.0 A (minimum phasor difference between any 2 phases to allow 21P Trip)

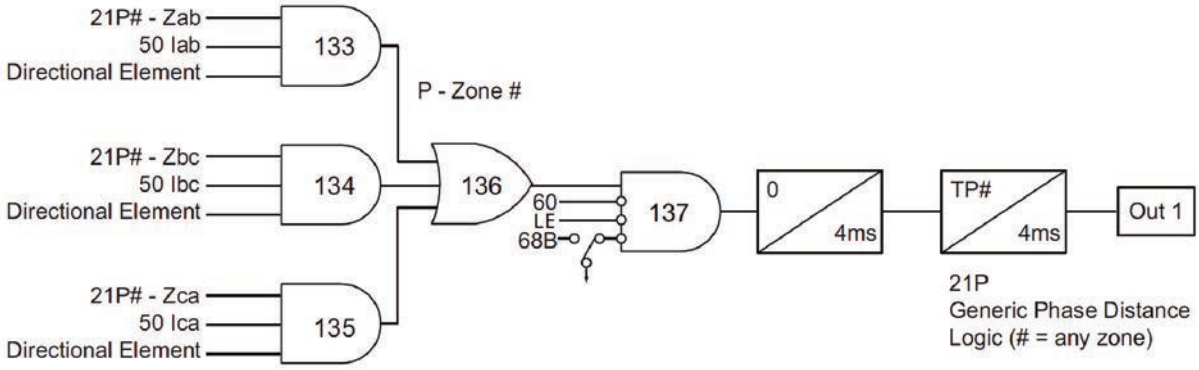


Figure 7.11: Phase Distance Logic (21P)

Preliminary Calculations

Since this is a balanced 3-phase test, there is no Zero Sequence Current, so Z is calculated as:

$$Z = \frac{V_{Phase}}{I_{Phase}} \tag{17}$$

where

Z - Phase Impedance
V_{Phase} - Phase Voltage
I_{Phase} - Phase Current

The minimum 3-phase current required is:

(Remember: I_{Delta} is the phasor difference between any 2-phase currents; add 5% to ensure the Minimum $I_{DeltaSupervision}$ Logic is high for this test).

$$I_{min} = \frac{I_{DeltaSupervision} \times 105 percent}{\sqrt{3}} = \frac{7.0 \times 1.05}{\sqrt{3}} = 4.24 amps \quad (18)$$

where

I_{min}- Minimum Current setting

$I_{DeltaSupervision}$ - Phase difference between any 2-phase currents

21P1 Test Procedure

1. In Relay Control Panel access relay *Metering>Logic>Protection.*
   Monitor 21P1 Zone 1Trip
2. Apply balanced 3-phase nominal voltages (66.4 V) to the relay terminals.
   Ph A: 330, 66.4 V ∠0°
   Ph B: 331, 66.4 V ∠-120°
   Ph C: 332, 66.4 V ∠+120°
   Ph N: 333
3. Connect 3-phase current sources (4.24 A lagging voltages by 80°) to the relay terminals:
   Ph A: 300 – 301, 4.24 A ∠–80°
   Ph B: 302 – 303, 4.24 A ∠–200°
   Ph C: 304 – 305, 4.24 A ∠+40°
   Observe 21P1 Trip = Low
4. Simultaneously reduce 3-phase voltages.
   At 21.0 to 19.0 V (expect 20.0 V)
   21 Trip = High (Note that Contact 1 will probably close earlier than 21-1 Trip going high, because Z2 and Z3 trip elements are mapped to the same output contact, and the length of time this fault will be applied.)

Testing the Zone 1 Phase Time Delay

1. Monitor (Timer Stop) on normally open Output Contact 1 (202 – 203).
2. Set timer to start from 3-phase amp current transition (i.e. current off to on).
3. Apply (keep on) balanced 3-phase voltages (20.0 V) to the relay terminals.
   Ph A: 330, 20.0 V ∠0°
   Ph B: 331, 20.0 V ∠-120°
   Ph C: 332, 20.0 V ∠+120°
   Ph N: 333
4. Apply 3-phase currents from 0 to 5.3 A to start the timer (this is 80% of Zone 1 Reach = 64% of the line = 12.4 miles).

Ph A: 300 – 301, 5.3 A – ∠-80°

Ph B: 302 – 303, 5.3 A – ∠-200°

Ph C: 303 – 304, 5.3 A – ∠+40°

Expect operating time less than 1.3 cycles with CCVT algorithm disabled.

End of 21P1 test.

21P2 Phase Distance Test

Zone 2 Phase Under Impedance tested as 2-phase fault

Settings

- Positive Sequence Secondary Line Impedance (100% of line) = 5.9 Ω Positive Sequence Line Angle (Z1) = 80°
- 21P2= 7.38 Ω (Maximum Reach = 125% of line, 24.25 miles at maximum torque angle of 80°)
- Time Delay = 400 ms (expect 1.0 to 1.3 cycle additional delay due to inherent detection and contact times)
- Delta Current Supervision = 3.0 A (minimum phasor difference between any 2 phases to allow 21P2 Trip)

This test example shows how to test for a phase-to-phase fault.

Determine the voltage and current quantities required to perform this test.

1. Determine the minimum current required (as per Idelta supervision setting).
2. Determine an appropriate fault voltage to use for the test.
3. Determine the 3-phase voltage phasors required to create the fault voltage.

1. Minimum current required for this test:

   I delta Supervision Setting (the phasor difference of 2 phases) = 3.0 A. Current is injected into polarity of B-phase and out of polarity of C-phase. Therefore B-phase and C-phase currents are equal in magnitude but 180° out of phase.

The minimum delta current required = 3.0 A; add 5% to ensure supervision is met:

$$3.0 \times 105\,percent = 3.2A \tag{19}$$

Since B-phase = C-phase, actual minimum current required is equal to

$$\frac{3.2}{2} = 1.6A \tag{20}$$

2. Use the minimum test current to determine what voltage would be appropriate for this test.

$$Z = \frac{V_{FaultMin}}{2 \times I_{TestMin}} \quad (21)$$

From Equation (21) we can derive the formula:

$$V_{FaultMin} = Z \times 2 \times I_{TestMin} \quad (22)$$

And using appropriate values, the Minimum Fault Voltage is

$$V_{FaultMin} = 7.38\Omega \times 2 \times 1.6A = 23.6V \quad (23)$$

where

$V_{FaultMin}$ - Minimum Fault Voltage
$I_{TestMin}$ - Minimum Fault Test Current

3. Now determine the 3-phase voltage phasors.

   Only B-C fault is shown here, but the same principle applies for A-B or C-A faults.

   Since neutral is not involved in this type of fault, the faulted voltage phasors collapse toward each other along the phase-to-phase line.

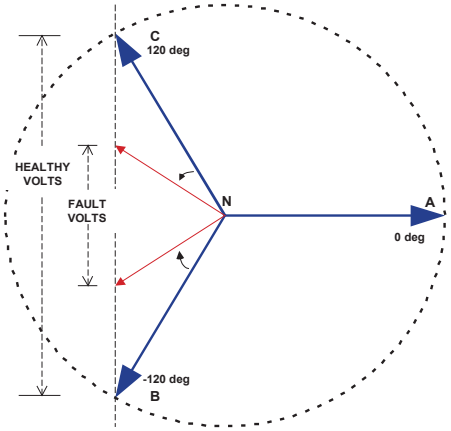


Figure 7.12: Phasor Representation of an Ideal Phase-to-Phase Fault

The following tables show the voltages to inject for a variety of fault voltage levels using 115 V secondary phase-to-phase nominal (66.4 V phase-to-neutral nominal).

Table 7.14: A-B Fault Voltage Injections

A-B Fault									
(C-phase voltage = 66.4 V ∠+120°) The resultant angle of A-B voltage always = +30°									
% Reduction	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
Fault V	103.5 V	92.0 V	80.5 V	69.0 V	57.5 V	46.0 V	34.5 V	23.0 V	11.5 V
Fault Volt Angle	30°	30°	30°	30°	30°	30°	30°	30°	30°
Voltage A=B	61.5 V	56.7 V	52.2 V	47.9 V	43.9 V	40.4 V	37.4 V	35.1 V	33.7 V
A Angle	-2.7°	-5.8°	-9.5°	-13.9°	-19.1°	-25.3°	-32.5°	-40.9°	-50.2°
B Angle	-117.3°	-114.2v	-110.5°	-106.1°	-100.9°	-94.7°	-87.5°	-79.1°	-69.8°

Table 7.15: B-C Fault Voltage Injections

B-C Fault									
(A phase voltage = 66.4 V $\angle 0^\circ$) The resultant angle of B-C voltage always = -90°									
% Reduction	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
Fault V	103.5 V	92.0 V	80.5 V	69.0 V	57.5 V	46.0 V	34.5 V	23.0 V	11.5 V
Fault Volt Angle	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°	-90°
Voltage B=C	61.5 V	56.7 V	52.2 V	47.9 V	43.9 V	40.4 V	37.4 V	35.1 V	33.7 V
B Angle	-122.7°	-125.8°	-129.5°	-133.9°	-139.1°	-145.3°	-152.5°	-160.9°	-170.2°
C Angle	122.7°	125.8°	129.5°	133.9°	139.1°	145.3°	152.5°	160.9°	170.2°

Table 7.16: C-A Fault Voltage Injections

C-A Fault									
(B phase voltage = 66.4 V $\angle$-120°) The resultant angle of C-A voltage always = +150°									
% Reduction	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
Fault V	103.5 V	92.0 V	80.5 V	69.0 V	57.5 V	46.0 V	34.5 V	23.0 V	11.5 V
Fault Volt Angle	150°	150°	150°	150°	150°	150°	150°	150°	150°
Voltage C=A	61.5 V	56.7 V	52.2 V	47.9 V	43.9 V	40.4 V	37.4 V	35.1 V	33.7 V
C Angle	117.3°	114.2°	110.5°	106.1°	100.9°	94.7°	87.5°	79.1°	69.8°
A Angle	2.7°	5.8°	9.5°	13.9°	19.1°	25.3°	32.5°	40.9°	50.2°

For this B-C test a minimum fault voltage of 23.6 V is required as calculated in “B-C Fault Voltage Injections, for details see Table 7.15: B-C Fault Voltage Injections on page 7-19. Select the next highest voltage. In this case 34.5 V (70% reduction) is used.

The following formulae were used to calculate the voltages for the tables (they may be used for any other desired fault voltage):

$$\text{Test voltage magnitude} = \sqrt{\left(\frac{V_{Fault}}{2}\right)^2 + \left(\frac{V_{Nominal}}{2}\right)^2} \quad (24)$$

where

V_{Fault} - phase-to-phase fault voltage

$V_{Nominal}$ - phase-to-neutral nominal voltage

Test Phase Angle

Offset the nominal phase angles toward the other faulted phase angle by:

$$60° - \text{atan}\left(\frac{V_{Fault}}{V_{Nominal}}\right) \quad (25)$$

Example of this calculation using the 70% voltage reduction from the B-C fault, for details see Table 7.15: B-C Fault Voltage Injections on page 7-19: Phase B-C voltage angle = -90° with respect to A-N voltage phasor.

Fault Voltage = 70% reduction of phase-to-phase nominal

$$= 115V - (\angle -90°) - (115V + \angle -90° \times 70 percent) = (34.5V(\angle -90°)) \quad (26)$$

$$\text{Faulted Test Voltage Magnitudes} = \sqrt{\left(\frac{34.5}{2}\right)^2 + \left(\frac{66.4}{2}\right)^2} = \sqrt{1399.8} = 37.4V \quad (27)$$

$$\text{Faulted Phase Angle} = 60° - \text{atan}\left(\frac{34.5}{66.4}\right) = 60° - 27.5° = 32.5° \quad (28)$$

For B-C fault adjust Phase B angle toward Phase C angle and adjust Phase C angle toward Phase B angle:

B Phase Angle = -120° - 32.5° = -152.5°

C Phase Angle = +120 +32.5° = 152.5°

So,

A Phase Phasor = Unfaulted = 66.4 V ∠0°

B Phase Phasor = Faulted = 37.4 V ∠-152.5°

C Phase Phasor = Faulted = 37.4 V ∠+152.5°

Connecting the Test Source for B-C Fault:

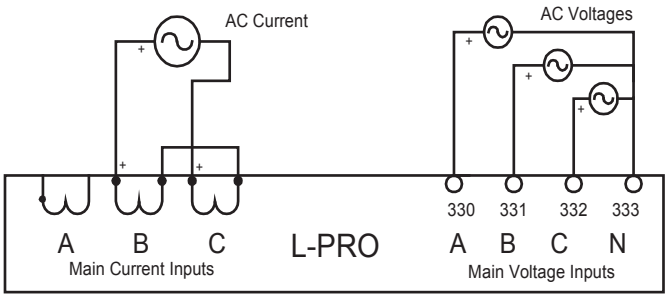


Figure 7.13: AC Connections to the relay for B-C (21P) Test

In summary for this example, inject Phase B to Phase C fault:

Line Impedance = 7.38 Ω

Line Angle = 80°

Fault Voltage = 34.5 V ∠-90° using the calculated voltage phasors

Fault Current = greater than 1.6 A ∠(-90°- 80°) = greater than 1.6 A ∠-170°

21P2 Test Procedure

1. In Relay Control Panel access relay *Metering>Logic>Protection.*
   Monitor the following element for pickup: 21P2 Zone 2 Pickup.
2. Apply the following 3-phase voltages to the relay main ac V terminals:
   Ph A: 330, 66.4 V ∠0°
   Ph B: 331, 37.4 V ∠-152.5°
   Ph C: 332, 37.4 V ∠+152.5°
   Ph N: 333
3. Connect variable single-phase current source (lagging phase-to-phase fault voltage by 80°) to the relay main line current terminals (Jumper Terminals 303 & 305):
   Ph B-C: 302 – 304, 1.5 A ∠-170°
   Observe 21P2 Alarm = Low
4. Increase current.
   At 2.23 to 2.45 A (expect 2.34 A):
   21P2 Alarm = High
5. Turn off voltage and current sources.

End of 21P2 test.

21N2 Ground Distance Test

Zone 2 Phase-to-Neutral Under Impedance

Settings

- Positive Sequence Secondary Line Impedance (100% of line) = 5.9 Ω
- Positive Sequence Line Angle (Z1) = 80°
- 21N2 = 7.38 Ω (Maximum Reach = 125% of line at maximum torque angle of 80°) compensated as per 21N calculations to: 11.58 Ω ∠76.5°
- Resistive Component compensated to: 9.41 Ω ∠-3.5°
- Time Delay = 0 (expect 1.3 cycles, 22 ms or less)
- 3I0 Current Supervision = 1.5 A (minimum zero sequence current to allow 21N2 to operate)
- I Phase Current Supervision = 1.5 A (minimum phase current to allow 21N2 to operate)

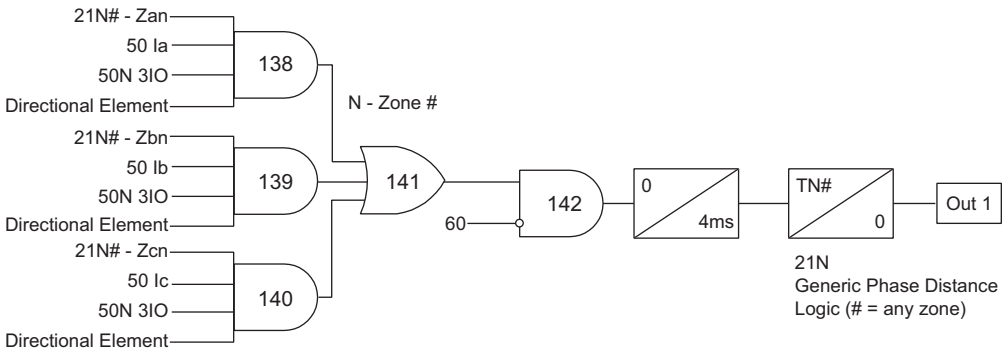


Figure 7.14: Ground Distance Logic (21N)

This test demonstrates testing a single line (Phase A) to a ground fault.

Preliminary calculations

Since this is a single-phase test, use the compensated impedance value calculated above; the calculated fault impedance Z_{fault} is:

$$Z_{fault} = \frac{V_{fault}}{I_{fault}} \quad (29)$$

The minimum single-phase current required is:

(Remember: Testing single-phase, so need to exceed the greater of I_{phase} and $3I_o$ supervision settings; add 5% to ensure the minimum supervision logic is high for this test):

$$I_{Min} = (\text{Greater of } I_{phase} \text{ and } 3I_o \text{ Supervision}) \text{x} 105\% = 1.5 \text{x} 1.05 = 1.58A \quad (30)$$

This element has been set for Quadrilateral characteristic.

21N2 Reactive Test Procedure

1. In Relay Control Panel access relay *Metering>Logic>Protection.*
   Monitor: 21N2 Zone 2 Pickup
2. Apply balanced 3-phase nominal voltages (66.4 V) to the relay terminals.
   Ph A: 330, 66.4 V ∠0°
   Ph B: 331, 66.4 V ∠-120°
   Ph C: 332, 66.4 V ∠+120°
   Ph N: 333
3. Connect single-phase current source to the relay terminals.
   Ph A: 300 – 301, 1.58 A ∠-76.5°
   Observe 21N2 Pickup = Low
4. Reduce Phase A voltage.
   At 17.4 to 19.2 V (expect 18.3 V):
   21N2 Pickup = High (After 400 ms: 21N2 Trip = High)

21N2 Resistive Test Procedure

1. In Relay Control Panel access relay *Metering>Logic>Protection.*
   Monitor: 21N2 Zone 2 Pickup
2. Apply balanced 3-phase nominal voltages (66.4 V) to the relay terminals.
   Ph A: 330, 66.4 V ∠0°
   Ph B: 331, 66.4 V ∠-120°
   Ph C: 332, 66.4 V ∠+120°
   Ph N: 333
3. Connect single -phase current source to the relay terminals.
   Ph A: 300 – 301, 1.58 A ∠+3.5°
   Observe 21N2 Pickup = Low
4. Reduce Phase A voltage.
   At 15.6 to 14.2 V (expect 14.9 V).
   21N2 Pickup = High
   After 400 ms: 21N2 Trip = High

Testing the Zone 2 Neutral Time Delay

1. Monitor (Timer Stop) on normally open Output Contact 1 (202 – 203).
2. Set timer to start from single-phase current transition (i.e. current off to on).
3. Apply the following 3-phase voltages to the relay terminals.

   Ph A: 330, 66.4 V ∠0°

   Ph B: 331, 66.4 V ∠-120°

   Ph C: 332, 66.4 V ∠+120°

   Ph N: 333
4. Apply single-phase current from 0 to 6.0 A to start the timer (95% of Zone 2 Reach = 119% of the line = 23.1 miles).

   Ph A: 300 – 301, 6.0 A ∠-76.5°

   Expected operate time = (400 ms + 1.0 to 1.3 cycle) = 417 ms (¬± 2.5%)
   Note: The zone timer starts when the fault is detected; the detection time + inherent contact time = approximately 1.0 to 1.3 cycles after fault inception.

Testing Other Zones

Test all other zones (21P3-4) and (21N1 and 21N3-4) using the same process as the 21P1, 21P2 and 21N2 zones, except that the user needs to substitute the impedance and timing settings for those zones.

End of 21 tests.

Load Encroachment Test

Load Encroachment function operates based on the fact that all phase-to-phase impedances (Zab, Zbc and Zca) are within the limited load angle area.

Load Encroachment Test Procedure

1. Use the following load encroachment settings together with above 21P setting.

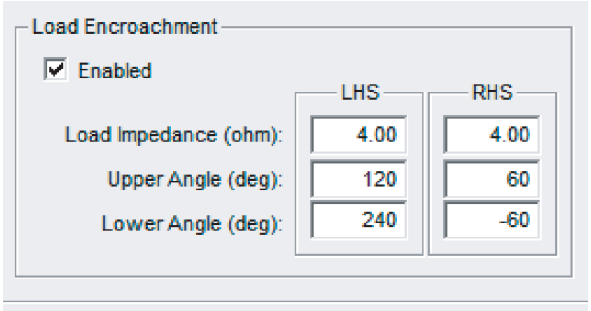


Figure 7.15: Load Encroachment Settings

2. Apply the following 3-phase voltages to the relay main ac V terminals:

   Ph A: 330, 62.0 V <0°

   Ph B: 331, 62.0 V <240°

   Ph C: 332, 62.0 V <120°

   Ph N: 333

3. Apply the following 3-phase currents to the relay main ac current terminals:
   Ph A: 300 – 301, 5.3 A <-30°
   Ph B: 302 – 303, 5.3 A <210°
   Ph C: 304 – 305, 5.3 A <90°
4. Observe target Load Encroachment.
5. Disable Load Encroachment, repeat steps 2-3.
6. Observe 21P3 Alarm/Trip.

End of Load Encroachment test.

Weak Infeed Test

Weak Infeed tripping operates on 4 basic conditions:

1. Low Positive Sequence Voltage (27V1) or High Neutral Voltage (59V0)
2. No Zone 2 or Zone 4 reverse element picked up.
3. Loss of Potential (60) element dropped out
4. Permissive trip received from the remote end

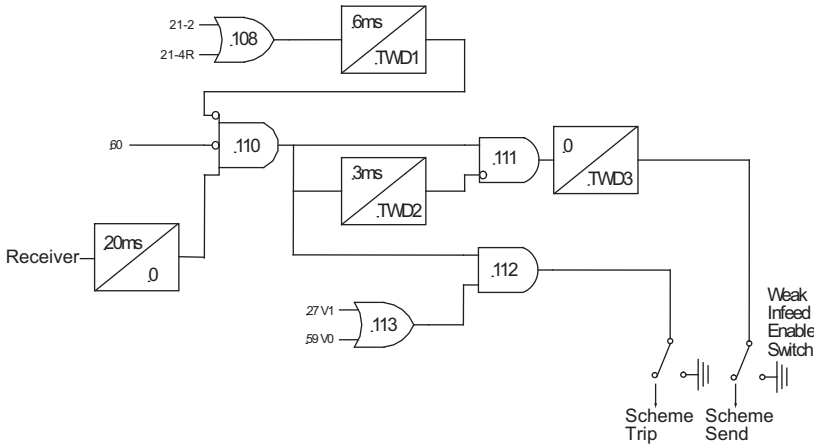


Figure 7.16: Weak Infeed Logic

For this test apply 0 voltage and 0 current to the relay with no prefault. This causes the first 3 conditions to be met: (27V1, NOT (Zone 2 OR Zone 4R), NOT Loss of Potential).

In this case a Virtual Input is set up to simulate the Permissive Trip Receive contact via ProLogic.

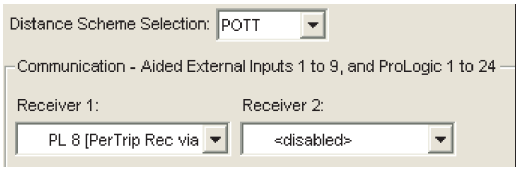

Distance Scheme Selection: POTT
Communication - Aided External Inputs 1 to 9, and ProLogic 1 to 24
Receiver 1:
Receiver 2:
PL 8 [PerTrip Rec via
<disabled>

Figure 7.17: Scheme Selector Settings (Offliner)

Weak Infeed Test Procedure

1. Activate this Virtual Input by accessing the Relay Control Panel's *Utilities >Virtual Inputs*.
2. Select *Virtual Input 13* in the Virtual Input drop down list.
3. Click on the *Pulse On* button to execute the "PerTripRec Simulate" as shown in the following screen shot.

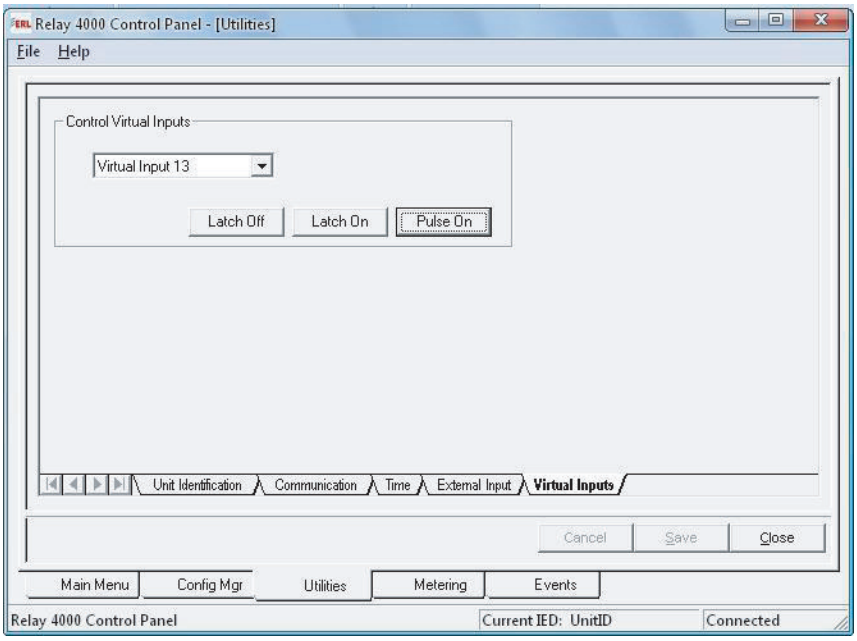


Figure 7.18: Virtual Input Control

Observe Relay Target: "POTT Trip (WI): 0.0 mi.

Note: The 0.0 mi indicates that there was 0 impedance measured due to 0 line voltage being applied.

End of Weak Infeed test.

Switch-On-To-Fault Test

Switch-On-To-Fault can be configured to operate based on two methods.

1. Close Command (Circuit breaker close pulse)
2. Status Monitoring (Circuit breaker status)

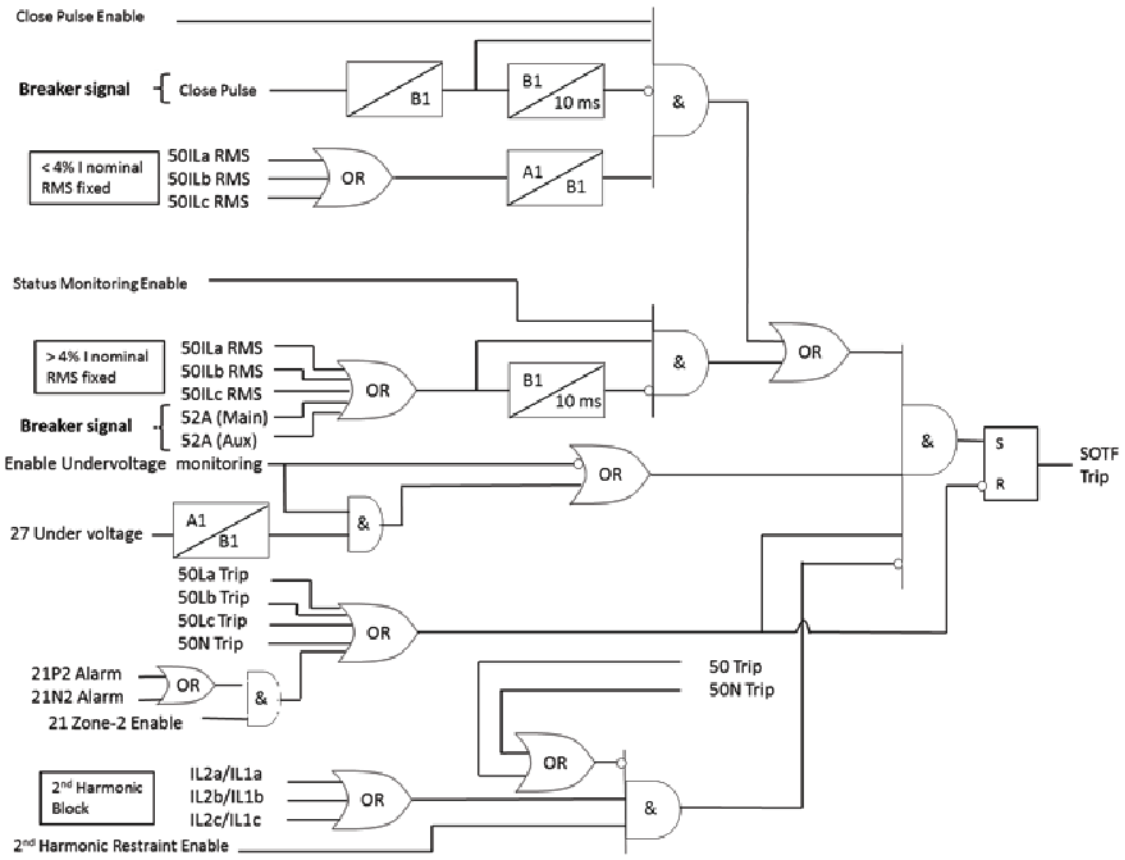


Figure 7.19: Switch-On-To-Fault Logic

Switch-On-To-Fault Test Procedure for Close Command Method

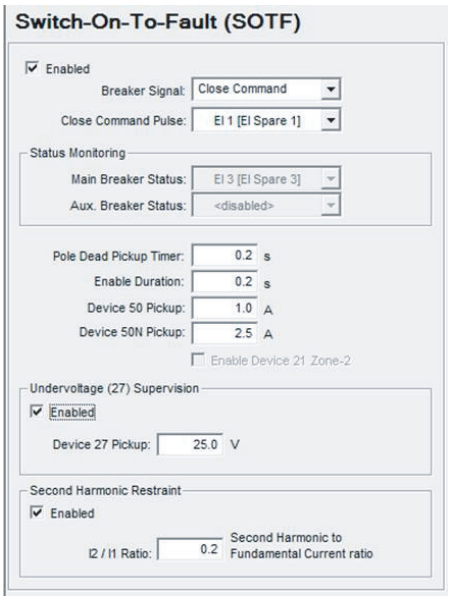

Switch-On-To-Fault (SOTF)
Enabled
Breaker Signal: Close Command
Close Command Pulse: EI 1 [EI Spare 1]
Status Monitoring
Main Breaker Status: EI 3 [EI Spare 3]
Aux. Breaker Status: <disabled>
Pole Dead Pickup Timer: 0.2 s
Enable Duration: 0.2 s
Device 50 Pickup: 1.0 A
Device 50N Pickup: 2.5 A
Enable Device 21 Zone-2
Undervoltage (27) Supervision
Enabled
Device 27 Pickup: 25.0 V
Second Harmonic Restraint
Enabled
I2 / I1 Ratio: 0.2
Second Harmonic to Fundamental Current ratio

Figure 7.20: Switch-On-To-Fault setting for Close Command (Offliner)

1. Objective of this test is to observe the basic operation of the logic. Disable 50, 50N, 21P2 and 21N2 functions.
2. Instantaneously, step three-phase current from 0 to 1.05 A to:

   Ph-A: 300 – 301, 1.05 A< 30°

   Ph-B: 302 – 303, 1.05 A< -90°

   Ph-C: 304 – 305, 1.05 A< 150°

   Voltage from 0 to 20 V to:

   Ph-A: 330 – 333, 20.0 V< 0°

   Ph-B: 331 – 333, 20.0 V< -120°

   Ph-C: 332 – 333, 20.0 V< 120°

   AND

   External Input- 1 from Low to High.

   Analog inputs can be delayed by 1 – 3 cycles to simulate the delay in circuit breaker operation.
3. Observe target Switch-On-To-Fault on ABC.

End of Switch-On-To-Fault Close Command test.

Switch-On-To-Fault Test Procedure for Status Monitoring Method

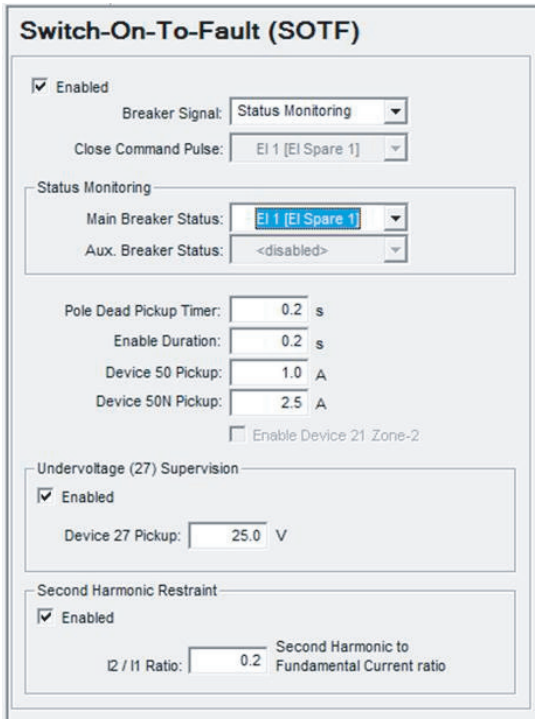

Switch-On-To-Fault (SOTF)
Enabled
Breaker Signal: Status Monitoring
Close Command Pulse: EI 1 [EI Spare 1]
Status Monitoring
Main Breaker Status: EI 1 [EI Spare 1]
Aux. Breaker Status: <disabled>
Pole Dead Pickup Timer: 0.2 s
Enable Duration: 0.2 s
Device 50 Pickup: 1.0 A
Device 50N Pickup: 2.5 A
Enable Device 21 Zone-2
Undervoltage (27) Supervision
Enabled
Device 27 Pickup: 25.0 V
Second Harmonic Restraint
Enabled
I2 / I1 Ratio: 0.2
Second Harmonic to Fundamental Current ratio

Figure 7.21: Switch-On-To-Fault setting for Status Monitoring (Offliner)

1. Objective of this test is to observe the basic operation of the logic. Disable 50, 50N, 21P2 and 21N2 functions.
2. During this test, the Main Breaker Status input (connected to EI-1) is used activate the SOTF logic. Ring bus configuration shall be disabled to disable the Aux Breaker Status input.
3. Instantaneously, step three-phase current from 0 to 1.05 A to:

   Ph-A: 300 – 301, 1.05 A< 30°

   Ph-B: 302 – 303, 1.05 A< -90°

   Ph-C: 304 – 305, 1.05 A< 150°

   Voltage from 0 to 20 V to:

   Ph-A: 330 – 333, 20.0 V< 0°

   Ph-B: 331 – 333, 20.0 V< -120°

   Ph-C: 332 – 333, 20.0 V< 120°

   AND

   External Input- 1 from Low to High.

   Analog inputs can be delayed by 1 – 3 cycles to simulate the delay in circuit breaker operation.
4. Observe target Switch-On-To-Fault on ABC.

End of Switch-On-To-Fault Status Monitoring test.

68 Power Swing

(Set to trip for this test.)

Settings

- Outer Right Blinder = 17 ohm
- Outer Left Blinder = -17 ohm
- Inner Right Blinder = 13 ohm
- Inner Left Blinder = -13 ohm
- Top Outer Blinder = 27 ohm
- Top Inner Blinder = 18 ohm
- Bottom Inner Blinder = -18 ohm
- Bottom Outer Blinder = - 27 ohm
- Swing timer = 1.0 second
- I_1 Supervision (positive sequence current) = 3.0 A
- 3_{I0} Supervision = 1.0 A

Note: Out of Step Blinders are Positive Sequence Impedance Quantities.

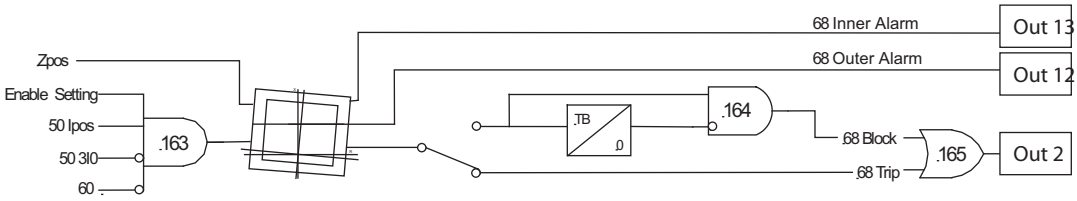


Figure 7.22: Power Swing (68)

Preliminary Calculations

Because this is a Positive Sequence Impedance, perform this test as balanced 3-phase, since this is the easiest way to obtain positive sequence. The calculated Z is:

$$Z = \frac{V_{Phase}}{I_{Phase}} \quad (31)$$

where

Z - Fault Impedance
V_{Phase} - Phase Voltage
I_{Phase} - Phase Current

The minimum 3-phase current required must be greater than the $I_{1Supervision}$ Setting (3.0 A). Add 5% to ensure that the supervision is met:

$$I_{Min} = I_{1Supervision} \text{ x } 105\% = 3.0 \text{ x } 1.05 = 3.15A \quad (32)$$

where

I_{Min} - Minimum Current

$I_{1Supervision}$ - Positive Sequence Supervision current setting

68 Outer Right Test Procedure

1. In Relay Control Panel access relay *Metering>Logic>Protection*.
   Monitor:
   68 OutBlinder Alarm
   Contact 12 with an ohmmeter
2. Apply balanced 3-phase nominal voltages (66.4 V) to the relay terminals.
   Ph A: 330, 66.4 V ∠0°
   Ph B: 331, 66.4 V ∠-120°
   Ph C: 332, 66.4 V ∠+120°
   Ph N: 333
3. Connect 3-phase current sources (3.15 A in phase with voltages) to the relay terminals: Ph A: 300 – 301, 3.15 A ∠0°
   Ph B: 302 – 303, 3.15 A ∠-120°
   Ph C: 303 – 304, 3.15 A ∠+120°
   Observe 68 OutBlinder Alarm = Low
   Contact 12 = Open
4. Simultaneously increase (ramp up) 3-phase currents.
   At 3.72 to 4.10 A (expect 3.91A):
   68 OutBlinder Alarm = High
   Contact 12 = Closed

End of 68 Outer test.

68 Inner Left Test Procedure

1. In Relay Control Panel access relay *Metering>Logic>Protection*.
   Monitor:
   68 InnBlinder Alarm.
   Output Contact 13 with an ohmmeter.
2. Apply balanced 3-phase nominal voltages (66.4 V) to the relay terminals:
   Ph A: 330, 66.4 V ∠0°
   Ph B: 331, 66.4 V ∠-120°
   Ph C: 332, 66.4 V ∠+120°
   Ph N: 333

3. Connect 3-phase current sources (3.15 A ∠180° from voltages) to the relay terminals.

   Ph A: 300 – 301, 3.15 A ∠180°

   Ph B: 302 – 303, 3.15 A ∠+60°

   Ph C: 304 – 305, 3.15 A ∠-60°

   Observe 68 InnBlinder Alarm = Low

   Contact 13 = Open

4. Simultaneously increase (ramp up) 3-phase currents.

   At 4.86 to 5.36 A (expect 5.11 A):

   68 InnBlinder Alarm = High

   Contact 13 = Closed

Testing the 68 Swing Timer Delay

1. Monitor (Timer Stop) on normally open Output Contact 2 (204 – 205).
2. Test at impedance between Inner and Outer Right Blinders = 15 Ω ∠0°
3. Set timer to start from 3-phase current transition (i.e. current off to on).
4. Apply (keep on) balanced 3-phase voltages (66.4 V) to the relay terminals.

   Ph A: 330, 66.4 V ∠0°

   Ph B: 331, 66.4 V ∠-120°

   Ph C: 332, 66.4 V ∠+120°

   Ph N: 333

5. Apply 3-phase currents from 0 to 4.43 A to start the timer.

   Ph A: 300 – 301, 4.43 A ∠0°

   Ph B: 302 – 303, 4.43 A ∠-120°

   Ph C: 304 – 305, 4.43 A ∠120°

   Expect operating time 1.0 second + inherent 1.0 to 1.3 cycle detection time.

   Observe target: “Out Of Step: Trip”.

End of 68 Swing Timer test.

Change Setting Group

For the next group of tests using the Acceptance Test file change to Setting Group 2.

1. In Relay Control Panel access *Utilities>Virtual Inputs*.
2. Select corresponding virtual input for “Switch to SG2”.
3. Click on *Pulse On* button to execute the command.
4. The Active Setting Group will become Group 2.

27 Undervoltage Test

Settings

- Main: AND (3-Phase Undervoltage)
- Auxiliary: AND (Single-Phase Undervoltage; Only 1 phase is connected)
- Main and Aux Pickup: 30 V
- Time Delay: 0.01 second

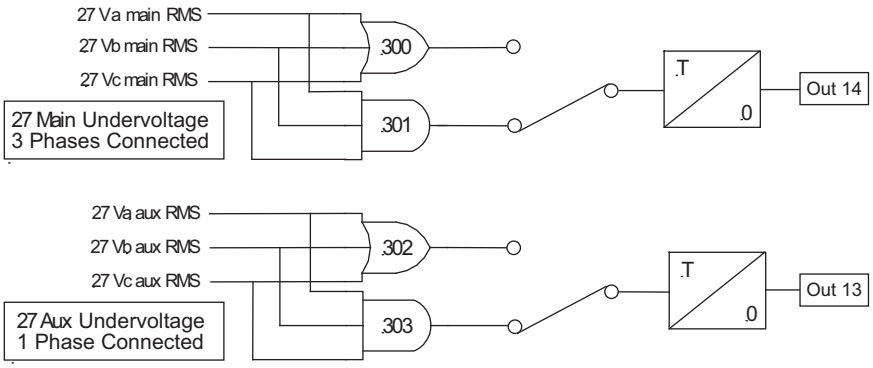


Figure 7.23: Undervoltage Logic (27)

27 Test Procedure

1. In Relay Control Panel access relay *Metering>Protection.*
   Monitor:
   27 Main U/V
   27 Aux U/V
   Monitor Output Contacts:
   13 (27 Aux Trip)
   14 (27 Main Trip)
2. Apply balanced 3-phase nominal voltages (66.4 V) to the relay terminals.
   Ph A: 324 and 330, 66.4 V ∠0°
   Ph B: 331, 66.4 V ∠-120°
   Ph C: 332, 66.4 V ∠+120°
   Ph N: 327 and 333
   Observe:
   27 Main U/V = Low
   27 Aux U/V = Low
3. Reduce A Phase voltage.
   At 31.0 to 29.0 V (expect 30 V):
   27 Aux U/V = High
   Contact 13 closed
   27 Main U/V remains Low
   Contact 14 open
4. With A Phase voltage still reduced, reduce B and C phase V:

At 31 to 29 V (expect 30 V):

27 Aux U/V = High

27 Main U/V = High

Contact 14 closed

End of 27 test.

59 Overvoltage Test

Settings

- Main 1 & 2: AND (3-Phase Overvoltage)
- Auxiliary 1&2: OR (Single-Phase Overvoltage - 1 phase connected)
- Main-1 & 2 and Aux-1 & 2 Pickup: 72 V
- Time Delay: 0.05 second

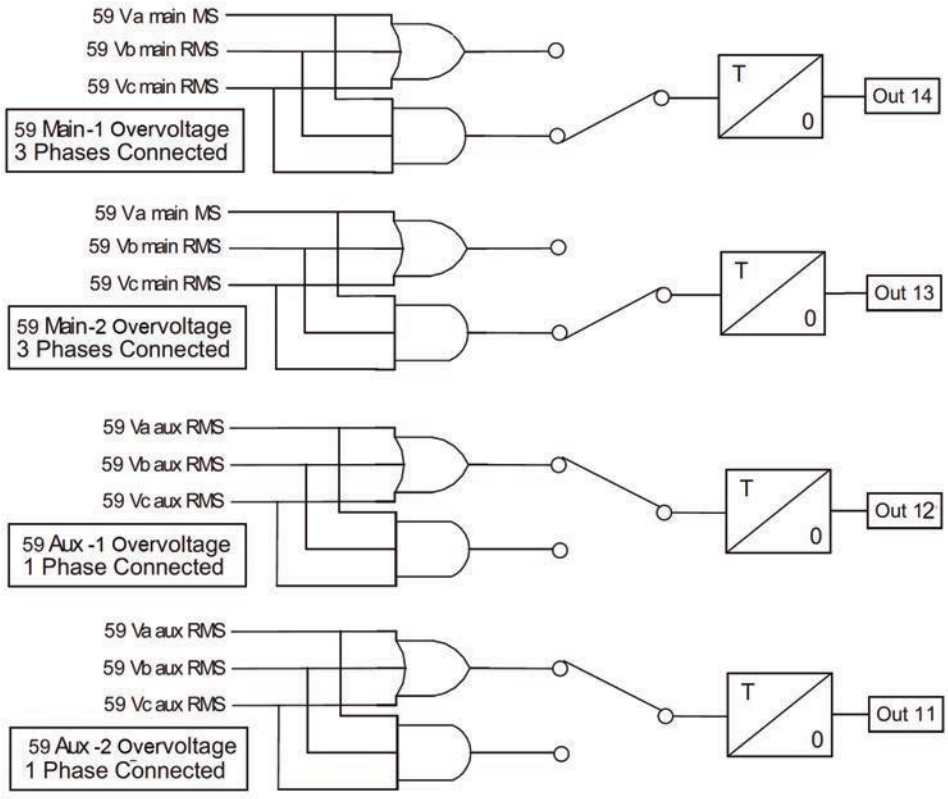


Figure 7.24: Overvoltage Logic (59)

59 Test Procedure

1. In Relay Control Panel access relay Metering>Protection.

   Monitor:

   59 Main-1 O/V

   59 Main-2 O/V

   59 Aux-1 O/V

59 Aux-2 O/V

Monitor contacts:

Output 11 (59 Aux-2 Trip)

Output 12 (59 Aux-1 Trip)

Output 13 (59 Main-2 Trip)

Output 14 (59 Main-1 Trip)

2. Apply balanced 3-phase nominal voltages (66.4 V) to the relay terminals.

   Ph A: 324 & 330, 66.4 V $< 0°$

   Ph B: 331, 66.4 V $< -120°$

   Ph C: 332, 66.4 V $< +120°$

   Ph N: 327 and 333

   Observe:

   59 Main-1 O/V = Low

   59 Main-2 O/V = Low

   59 Aux-1 O/V = Low

   59 Aux-2 O/V = Low

3. Increase A Phase voltage:

   At 70.0 to 74.0 V (expect 72 V):

   59 Aux 1&2 O/V = High

   Contact 11 &12 = Closed

   59 Main1&2 O/V remains Low

   Contact 13 & 14 = Open

4. With A Phase voltage still increased, increase B and C phase Voltage.

   At 70 to 74 V (expect 72 V):

   59 Aux 1 & 2 O/V = High

   59 Main 1 & 2 O/V = High

   Contact 13 & 14 = Closed

End of 59 test.

50N/51N Neutral Overcurrent Test

Neutral Instantaneous and Time Overcurrent Test

Settings

- Both Non-directional
- 50N Pickup = 10.0 A
- 51N Pickup = 1.0 A
- Time Curve = IEEE Moderately Inverse

  A = 0.0103

  B = 0.0228

  p = 0.02

  TMS = 3.0

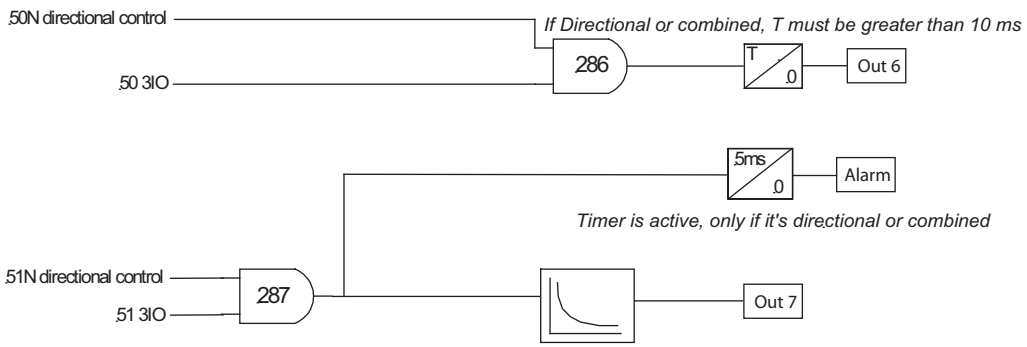


Figure 7.25: Neutral Instantaneous and Time Overcurrent Logic (50N/51N)

50N and 51N Test Procedure

Note: with 0 voltage applied, the unit becomes non-directional (i.e. picks up in both forward and reverse directions).

1. In Relay Control Panel access relay *Metering>Protection*.
   Monitor:
   51N Alarm
   Output Contact 6 (50N Trip)
2. Apply single-phase current to the relay terminals as follows:
   Ph A: 300 – 301, 0.5 A
3. Slowly ramp the current up.
   At 0.95 to 1.05 A (expect 1.0 A):
   51N Alarm = High
4. Continue to raise current.
   At 9.5 to 10.5 A (expect 10.0 A):
   50N Trip = High
   Contact 6 = Closed
5. Turn current off.
   51N Alarm = Low
   50N Trip = Low

Timing Test

1. Monitor (Timer Stop) on Output Contact 7.
2. Set timer start from single-phase 0.0 A to 4.00 A transition (this equates to 4x pickup).

$$\text{Time Delay} = TMS \times \left[B + \frac{A}{(I_{Multiple})^{p} - 1} \right] \quad (33)$$

$$= 3 \times \left[0.0228 + \frac{0.0103}{4^{0.02} - 1} \right] = 3 \times \left[0.0228 + \frac{0.0103}{0.0281} \right] = 1.168s$$

where

TMS - 3.0

$I_{Multiple}$ - 4.0

3. Inject fault.
   Observe Relay Target: “51N Trip”

End of 50N/51N test.

50/51 Phase Overcurrent Test

(Phase Instantaneous and Time Overcurrent) Test

Settings

- Only 51 Non-directional
- 50 Pickup = 15.0 A
- 51 Pickup = 1.5 A
- Time Curve = IEC Very Inverse

  A = 13.5
  B = 0.00
  p = 1.0
  TMS = 0.5

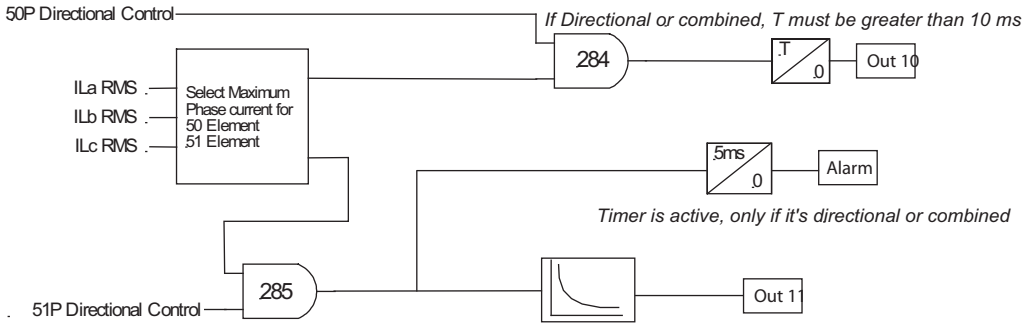


Figure 7.26: Phase Instantaneous and Time Overcurrent Logic (50/51)

50 and 51 Test Procedure

1. In Relay Control Panel access relay *Metering>Protection.*
   Monitor:
   51 Alarm.
   Output Contact 10 (50 Trip).
2. Apply single-phase current to the relay terminals.
   Ph A: 300 – 301, 0.5 A
3. Slowly ramp up the current.
   At 1.43 to 1.58 A (expect 1.5 A):
   51 Alarm = High
4. Continue to raise current.
   At 14.3 to 15.8 A (expect 15 A):
   50 Trip = High
   Contact 10 = Closed
5. Turn current off.
   51 Alarm = Low
   50 Trip = Low

51 Timing Test

1. Monitor (Timer Stop) on Output Contact 11.
2. Set timer start from single-phase 0.0 A to 6.00 A transition (this equates to 4x pickup).
3. Inject fault.

$$\text{Time Delay} = TMS \times \left[B + \frac{A}{(I_{multiple})^{p} - 1} \right]$$

$$= 0.5 \times \left[0.00 + \frac{13.5}{4^{1} - 1} \right] = 0.5 \times \left[0.00 + \frac{13.5}{3} \right] = 2.25s \qquad (34)$$

Observe Relay Target: “51 Trip on A”

51 Directional Test

Settings

- 51 Settings: directional/forward (if directional α = -170º, β = 180º)
- Line Angle = 80° (i.e. current lags voltage by 80°)

Note: Operating Range = ¬± 90° from line angle

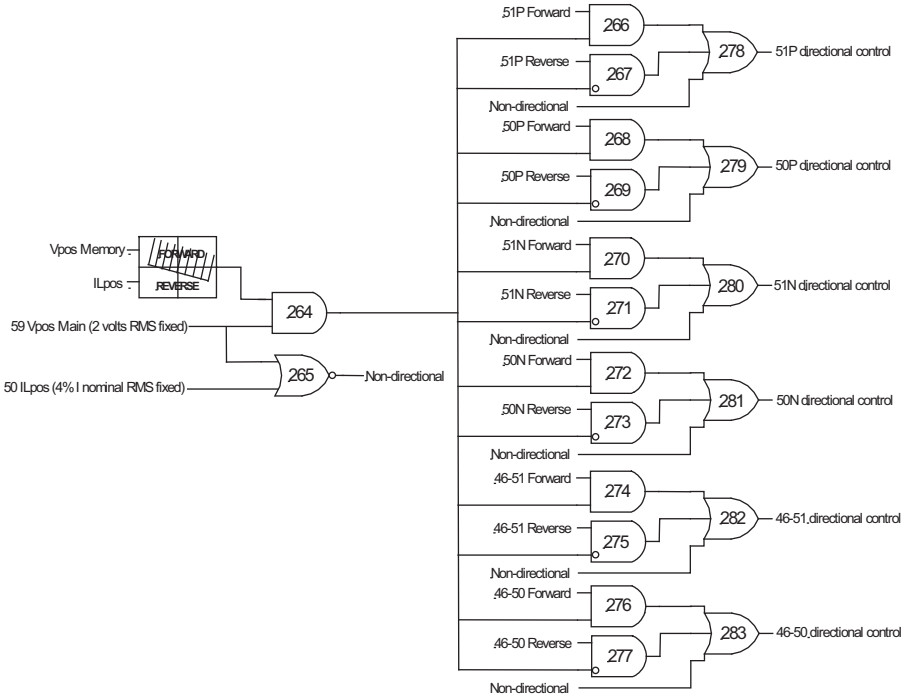


Figure 7.27: Directional Element Logic

51 Directional Test Procedure

1. In Relay Control Panel access relay *Metering>Protection*.
   Monitor: 51 Pickup Alarm
2. Apply single-phase polarizing voltage to:
   Ph A: 330 – 333, 66.4 ∠ V 0º
   Ph B: 331 – 333, 66.4 ∠ V -120º
   Ph C: 332 – 333, 66.4 ∠ V 120º
3. Apply single-phase current at line angle to:
   Ph A: 300 – 301, 2.0 A ∠-80°
   Observe 51 Pickup Alarm = High
4. Slowly ramp the current phase angle in negative direction (i.e. more lag):
   At -165° to -175° (expect -170°):
   51 Pickup Alarm = Low
5. Restore current to line angle (-80°):
   Observe 51 Pickup Alarm = High
6. Slowly ramp the current phase angle in positive direction (i.e. less lag):
   At +5° to +15° (expect +10°):
   51 Pickup Alarm = Low
7. Turn off voltage and current sources.

End of 50/51 test.

46-50/46-51 Negative Sequence Overcurrent Test

Settings

- Non-directional
- 46-51 Pickup = 1.0 A
- Time Curve = IEEE Extremely Inverse

  A = 5.64

  B = 0.02434

  p = 2

  TMS = 3.0

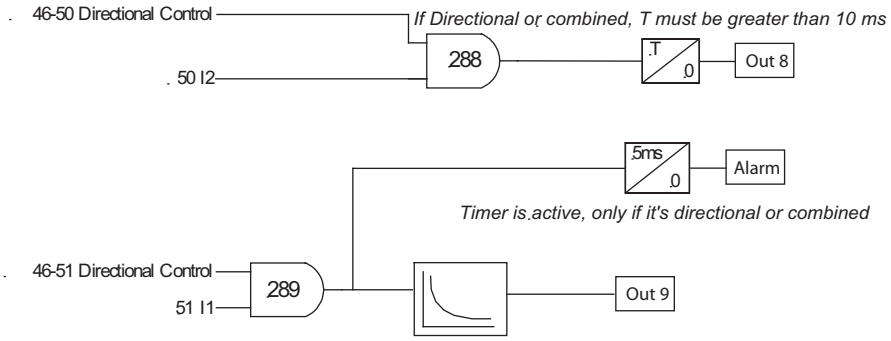


Figure 7.28: Negative Sequence Instantaneous and Time OverCurrent Logic (46-50/46-51)

Note that positive sequence current (50ILpos), 4% of nominal current is necessary to enable the directional element. This supervision can be seen on OR 265, for details see Figure 7.27: Directional Element Logic on page 7-39.

For this test inject only single-phase current. This method introduces an equal proportion of positive and negative sequence current. This assures that there is sufficient positive sequence current to enable directional control of the negative sequence element, if a polarizing voltage is also applied.

Positive sequence (I1), Negative Sequence (I2), Zero Sequence (3I0) are calculated by using the following equations:

$$I_1 = \frac{I_A + aI_B + a^2 I_C}{3} \text{ where a = 1 } \angle 120^\circ \quad (35)$$

$$I_2 = \frac{I_A + a^2 I_B + aI_C}{3} \text{ where a = 1 } \angle 120^\circ \quad (36)$$

$$3I_o = I_A + I_B + I_C \tag{37}$$

where

I_A - Phase A Current

I_B - Phase B Current

I_C - Phase C Current

Using Equation 6 notice that there is a need to triple the pickup setting current on one phase to obtain the pickup value of negative sequence current.

For example injecting 1.0 A on Phase A only (Phase B = Phase C = 0), and with no voltage applied, the 46-51 element becomes non-directional even though the setting is directional:

$$I_2 = \frac{1 + a^2 0 + a0}{3} = \frac{1}{3} = 0.33A \tag{38}$$

46-51 Test Procedure

1. In Relay Control Panel access relay *Metering>Protection*.
   Monitor: 46-51 Alarm
2. Apply single-phase current to the relay terminals as follows:
   Ph A: 300 – 301, 2.5 A
3. Slowly ramp the current up:
   At 2.9 to 3.1 A (expect 3.0 A):
   46-51 Pickup Alarm = High
4. Turn current source off.

46-51 Timing Test

1. Monitor (Timer Stop) on Output Contact 9.
2. Set timer start from single-phase 0.0 A to 12.00 A transition (this equates to 4x pickup).

$$\text{Time Delay} = TMS \times \left[B + \frac{A}{(I_{Multiple})^p - 1} \right]$$

$$= 3.0 \times \left[0.02434 + \frac{5.64}{4^2 - 1} \right] = 3.0 \times \left[0.02434 + \frac{5.64}{15} \right] = 1.201s \tag{39}$$

3. Inject fault.
   Observe Relay Target: “46-51 Trip”

End of 46-51 test.

50BF (Breaker Fail) and 50LS (Low Set Overcurrent) Tests

Settings

Main:

- 50LS Pickup: 1.0 A,
- Time Delay: 0.00 seconds
- 50BF Time Delay 1: 5.0 seconds
- 50BF Time Delay 2: 10.0 seconds

Auxiliary:

- 50LS Pickup: 1.0 A
- Time Delay: 0.00 seconds
- 50BF Time Delay 1: 5.0 seconds
- 50BF Time Delay 2: 10.0 seconds

Input 3:

- 50LS Pickup: 0.3 A
- Time Delay: 1.00 second

(50LS used with Virtual Input 3 to make Breaker Fail for Breaker 3)

Input 4:

- 50LS Pickup: 0.3 A
- Time Delay: 1.00 second

(50LS used with Virtual Input 4 to make Breaker Fail for Breaker 4)

Main and Aux. Breaker Fails are set to be initiated via the Output Matrix from 50LS Pickup (1.0 A Main and Aux and 0 time delay). Note: Requires a minimum of 0.2 A on any phase to arm Breaker Fail.

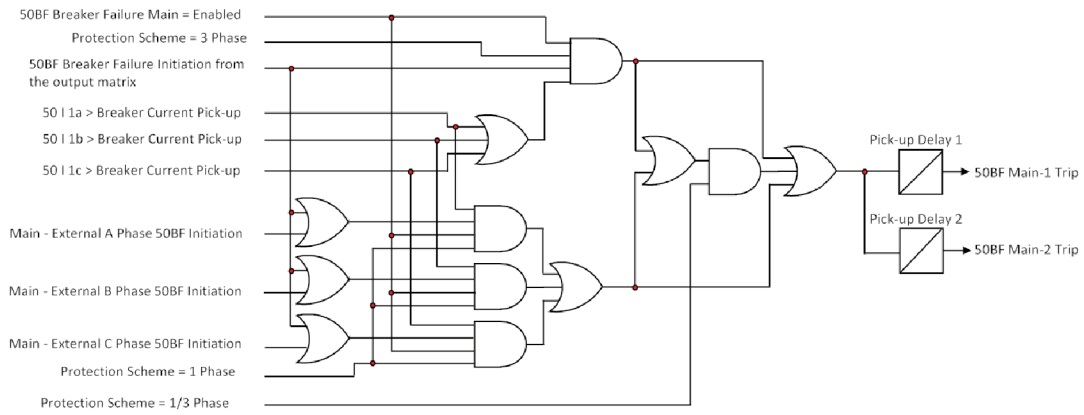

50BF Breaker Failure Main = Enabled
Protection Scheme = 3 Phase
50BF Breaker Failure Initiation from the output matrix
50 I 1a > Breaker Current Pick-up
50 I 1b > Breaker Current Pick-up
50 I 1c > Breaker Current Pick-up
Main - External A Phase 50BF Initiation
Main - External B Phase 50BF Initiation
Main - External C Phase 50BF Initiation
Protection Scheme = 1 Phase
Protection Scheme = 1/3 Phase
Pick-up Delay 1
50BF Main-1 Trip
Pick-up Delay 2
50BF Main-2 Trip

Figure 7.29: Main Breaker Fail Logic (50BF)

50BF and 50LS Test Procedure

1. In Relay Control Panel access relay *Metering>Protection.*
   Monitor:
   50LS Main
   Output Contact 1 (50BF Main-1 Trip: A)
   Output Contact 2 (50BF Main-2 Trip: A)
2. Apply single-phase current to the relay terminals as follows:
   Ph A: 300 – 301, 0.8 A
3. Slowly ramp the current up, at a rate of about 0.1 A per second:
   At 0.9 to 1.1 A (expect 1.0 A):
   50LS Main = High
   5 seconds later, Output Contact 1 = Closed (50BF Main-1 Trip)
   After an additional 5 seconds Output Contact 2 = Closed (50BF Main-2 Trip)
4. Turn current off.
   50LS Main = Low
   Contacts 1 and 2 = Open
5. The same 50BF procedure may be followed on the auxiliary input by injecting current into relay auxiliary current input, Terminals 306-307 and monitor Contacts 3 and 4.

Testing Inputs 3 and 4 50LS Function

Inputs 3 and 4 50LS functions are used in a Breaker Fail Application using ProLogic.

The following screen shot shows the Logic being used to make a Breaker Fail application from the 50LS using ProLogic.

ProLogic 1: This boolean equation used to initiate and operate as a Breaker Fail for 52-3 (Input 3). Current above the 50LS threshold arms one input of the

AND gate. The initiate in this case is provided by Virtual Input 3 which will latch until the current drops below the 50LS threshold.

Note: ProLogic 2 (not shown) is for 52-4 (Input 4).

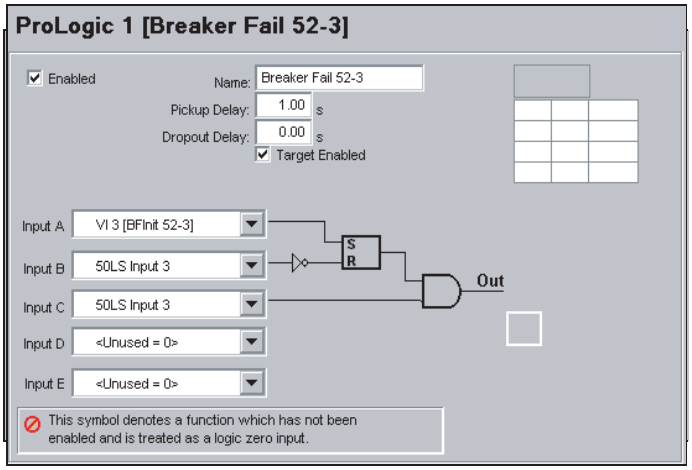


Figure 7.30: Breaker Fail Created Using ProLogic

Input 3 Breaker Fail Test Procedure

1. Apply 0.31 A to the relay Terminals 312 – 313.
2. In Relay Control Pane access *Utilities>Virtual Inputs.*

   Select Virtual Input 3 “Init BF 52-3”.

   Pulse On

   Observe after 1 Second: Target “Breaker Fail 52-3: PL1”.
3. Reduce current to zero.
4. Apply the same process to Input 4, Terminals 318 – 319, using Virtual Input 4 “Init BF2-4”.

End of 50BF and 50LS tests.

For the next group of tests using the Acceptance Test file, change to Setting Group 3.

1. In Relay Control Panel access *Utilities>Virtual Inputs.*
2. In the drop down list of virtual inputs, select the corresponding virtual input to “Switch to SG3”.
3. Cursor over to Action and select *Pulse On*.
4. Click on *Pulse On* to execute this command, the Active Setting Group is Group 3 now.

81 Overfrequency and Underfrequency Test

Settings

- 81-1 Pickup = 60.5 Hz Fixed Rate (50.5 Hz for 50 Hz Relay)
- 81-1 Time Delay = 0.5 second
- 81-2 Pickup = 59.5 Hz Fixed Rate (49.5 Hz for 50 Hz Relay)
- 81-2 Time Delay = 0.5 second
- 81-3 Pickup = +1.0 Hz/second
- 81-3 Time Delay = 0.2 second
- 81-4 Pickup = -1.0 Hz/second
- 81-4 Time Delay = 0.2 second

Requires minimum of 0.25 per unit positive sequence voltage (fixed setting) to enable the 81 element.

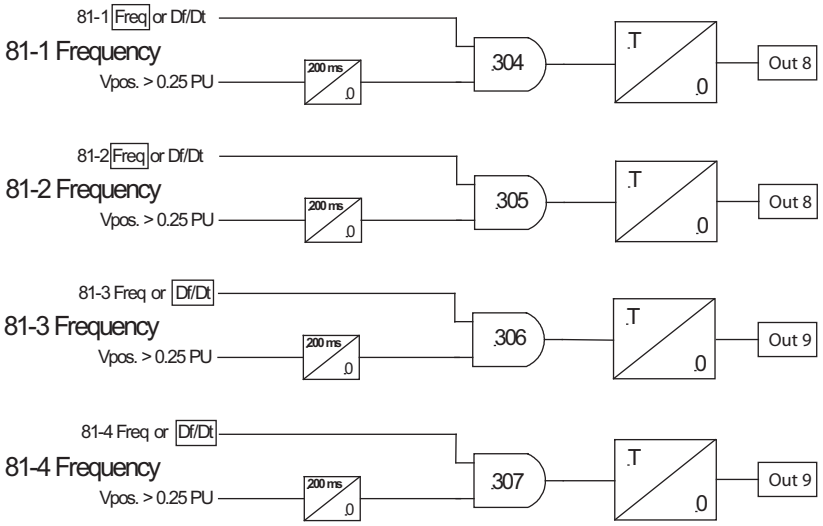


Figure 7.31: Over/Under/Rate of Change of Frequency Logic (81)

81 Fixed Rate Test Procedure

1. In Relay Control Panel access relay *Metering>Protection.*
   Monitor:
   81-1 Trip
   Output Contact: 8
2. Apply single-phase nominal voltage to:
   Ph A: 330 – 333, 66.4 V @ 60 Hz (@ 50 Hz for 50 Hz Relay)
   81-1 = Low
   81-2 = Low
3. Ramp up the voltage frequency.
   At 60.499 to 60.501 Hz (50.499 to 50.501 Hz for 50 Hz relay):
   81-1 = High

81-2 = Low

Contact 8 = Closed

4. Ramp down the voltage frequency.
   At 59.501 to 59.499 Hz (49.501 to 49.499 Hz for 50 Hz Relay):
   81-1 = Low
   81-2 = High
   Contact 8 = Closed
5. Turn voltage source off.

81 Rate of Change (df/dt) Test Procedure

1. In Relay Control Panel access relay *Metering>Protection.*
   Monitor:
   81-3 Trip
   Contact: 9
2. Apply single-phase nominal voltage to the relay terminals.
   Ph A: 330 – 333, 66.4 V @ 60 Hz (50 Hz for 50 Hz Relay)
   81-3 = Low
   81-4 = Low
3. Ramp the frequency at a rate of +0.99 Hz/s for a duration of 2 seconds.
   Observe:
   81-3 = Low
   81-4 = Low
   Contact 9 = Open
4. Restore nominal frequency.
5. Ramp the frequency at a rate of +1.01 Hz/s for a duration of 2 seconds.
   Observe:
   81-3 = High
   81-4 = Low
   Contact 9 = Closed
6. Restore nominal frequency.
7. Ramp the frequency at a rate of -0.99 Hz/s of a duration of 2 seconds.
   Observe:
   81-3 = Low
   81-4 = Low
   Contact 9 = Open
8. Restore nominal frequency.
9. Ramp the frequency at a rate of -1.01 Hz/s for a duration of 2 seconds.
   Observe:
   81-3 = Low
   81-4 = High
   Contact 9 = Closed

81 Timing Test Procedure

1. Monitor (Timer Stop) on Output Contact 8 (81-1).
2. Set timer start on instantaneous frequency shift 66.4 V @ 60 Hz to 60.6 Hz transition.

   Expect time delay of 500 ms + approximately 1.5 cycle detection time.
3. Apply the frequency shift.

   Confirm the expected time delay.

   Target “81-1”
4. Move (Timer Stop) to Output Contact 9 (81-2).
5. Set timer start on instantaneous frequency shift 66.4 V @ 60 Hz to 59.4 Hz transition.

   Expect time delay of 500 ms + approximately 1.5 cycle detection time.
6. Apply the frequency shift.

   Confirm the expected time delay.

   Target “81-2”

End of 81 test.

25/27/59 Sync Check Test

Note: Three or four voltage sources are required for this test.

The relay will create the positive sequence sync check voltage out of the single-phase auxiliary voltage input depending on which phase is injected.

Settings

- Maximum voltage: 70 V sec. (Maximum Positive Sequence voltage)
- Minimum voltage: 40 V sec. (Minimum Positive Sequence voltage)
- Angle Difference: 20 degrees
- Time Delay: 200 milliseconds
- Dead Main Live Aux. (DMLA): Enable
- Live Main Dead Aux. (LMDA): Enable
- Dead Main Dead Aux. (DMDA): Enable

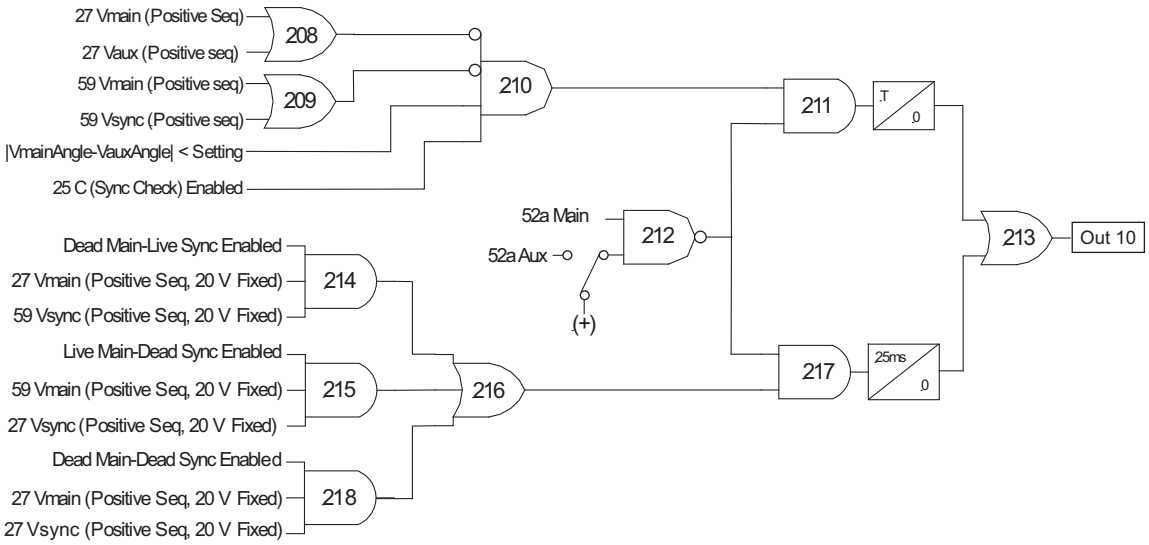


Figure 7.32: Synchronism Check Logic (25/27/59)

Sync Check Test Procedure

1. In Relay Control Panel access relay *Metering>Protection.*

   Monitor:

   25/27/59 Sync Check

   Output Contact: 10

   Observe 25/27/59 Sync Check = High (Proves DMDA with no voltage applied)

2. Apply voltages to the relay main voltage input terminals sufficient to create Vpos of 66.4 V.

   If only 3 voltage sources are available:

   Ph A: 330, 99.6 V ∠0°

   Ph B: 331, 99.6 V ∠-120°

   Ph C: 332, not applicable

   Ph N: 333

OR

   If 4 voltage sources are available:

   Ph A: 330, 66.4 V ∠0°

   Ph B: 331, 66.4 V ∠-120°

   Ph C: 332, 66.4 V ∠+120°

   Ph N: 333

   Observe 25/27/59 Sync Check = High (Proves Live Main Dead Aux (LM-DA) with only line voltage applied)

3. Turn voltage off.
4. Apply single-phase nominal voltage (120 V) to the relay auxiliary voltage input terminals.

   Ph A:324, 120 V ∠25° (Note: 3x Minimum Voltage = 3x40 =120 V this is for single-phase only)

   Ph N: 327

   (Short and ground unused Terminals 325 and 326)

   Observe 25/27/59 Sync Check = High (Proves DMLA with only bus-voltage applied)

5. Apply both sets of voltages to main and auxiliary inputs as detailed above.

   Observe:

   25/27/59 Sync Check = Low

6. Simultaneously rotate the auxiliary voltage phase angle in lagging direction (i.e. toward 0°).

   At 21° to 19° difference (expect 20°):

   25/27/59 = High

   Contact 10 = Closed (after 200 ms)

7. Slowly ramp down the auxiliary voltage magnitude.

   At 41.0 to 39.0 V (expect 40 V):

   25/27/59 = Low

Contact 10 = Open

8. Slowly ramp up the auxiliary voltage magnitude.

At 69.0 to 71.0 V (expect 70 V):

25/27/59 = Low

Contact 10 = Open

8. Turn all voltage sources off.

End of Sync Check test.

79 Recloser Test

Settings

- Number of Shots: 4
- First Reclose (T1): 2.0 seconds
- Second Reclose (T2): 4.0 seconds
- Third Reclose (T3): 6.0 seconds
- Fourth Reclose (T4): 8.0 seconds
- Close time (Tp): 0.3 second
- Lockout Reset (TD): 12 seconds
- Initiate Reset (TDI): 1.0 second
- Sync Control: Enable
- Mode: Main then Aux.
- Block Reset (TDB): 1.0 seconds
- Follower Time (TF): 8.0 seconds
- Breaker Out Of Service (TC): 200 seconds
- Follower Sequencer: Close after Recloser Follower Time
- Main Breaker: EI1 [Breaker Status a]
- Aux Breaker: EI2 [Breaker Status a]

The following procedure allows the user to test the Main and Auxiliary 4-shot reclosers, ending in 79 lockout.

The only test equipment required for this test is a 125 Vdc supply.

Output Contact 5 of the relay is used to simulate the Main Breaker “a” Contact and Output Contact 6 is used to simulate the Aux Breaker “a” Contact.

The Main Breaker Status is monitored by External Input 1; and Auxiliary Breaker Status is monitored by External Input 2.

Output 7 is used to simulate a protection operation. It supplies a trip command via External Input 3 and initiates the 79 operation.

Connect a 125 Vdc supply to the relay output and input terminals as shown, for details see Figure 7.33: Test Connections for 4-Shot Recloser Test on page 7-51.

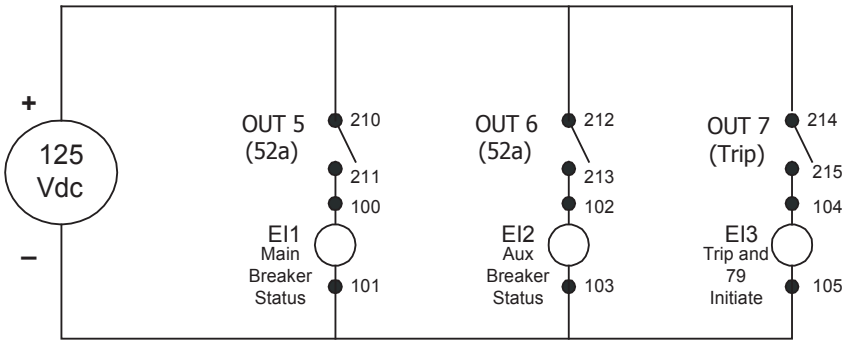


Figure 7.33: Test Connections for 4-Shot Recloser Test

ProLogic equations are used to activate and supervise the 79 test functions. Normally each of these ProLogic equations would not be set to target, but for this type of acceptance testing, it is convenient for seeing operations as they happen.

Details of ProLogic Equations for this 79 Test Example

ProLogic 1: This equation activates the reclose sequence. It sets the breaker status (closes Out 5) via ProLogic 3.

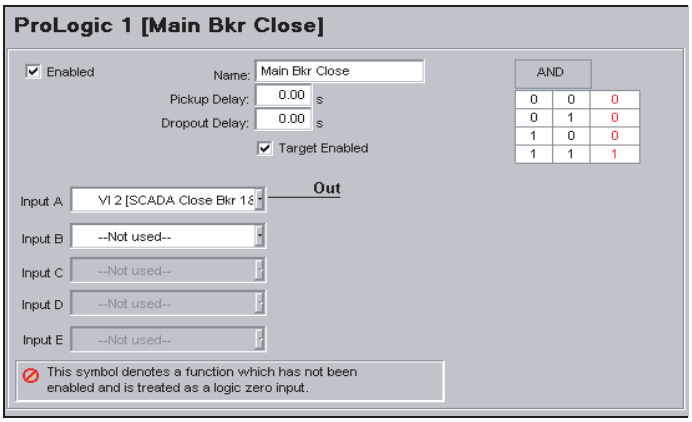

ProLogic 1 [Main Bkr Close]
Enabled
Name: Main Bkr Close
Pickup Delay: 0.00 s
Dropout Delay: 0.00 s
Target Enabled
AND
0 0 0
0 1 0
1 0 0
1 1 1
Out
Input A VI 2 [SCADA Close Bkr 18
Input B --Not used--
Input C --Not used--
Input D --Not used--
Input E --Not used--
This symbol denotes a function which has not been enabled and is treated as a logic zero input.

Figure 7.34: Simulating Main Breaker Close Command using Virtual Input in ProLogic

ProLogic 2: This equation is used to reset the Main Breaker Status via ProLogic 3 (Opens Out 5).

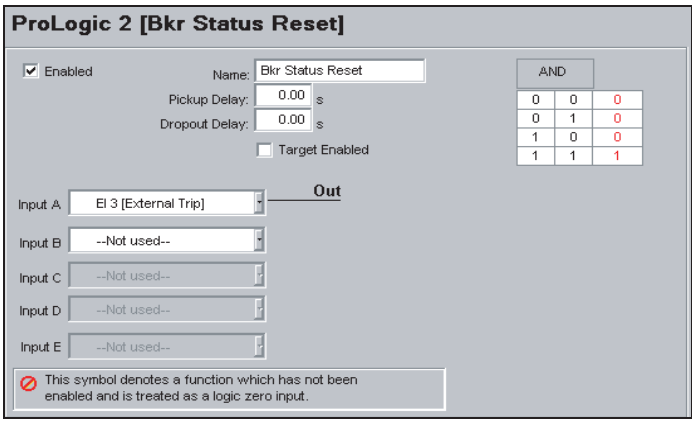

ProLogic 2 [Bkr Status Reset]
Enabled
Name: Bkr Status Reset
Pickup Delay: 0.00 s
Dropout Delay: 0.00 s
Target Enabled
AND
0 0 0
0 1 0
1 0 0
1 1 1
Out
Input A EI 3 [External Trip]
Input B --Not used--
Input C --Not used--
Input D --Not used--
Input E --Not used--
This symbol denotes a function which has not been enabled and is treated as a logic zero input.

Figure 7.35: Breaker Status Reset using ProLogic (Ext. Input 3 via Output Contact 5)

ProLogic 3: This equation is set from ProLogic 1 (Main Breaker Close Command) OR ProLogic 9 (Main Breaker Reclose). (Note that ProLogic 9 is mapped to Out 14, so Out 14 is used to indirectly provide ProLogic 9 availability to ProLogic 1 through 8.) ProLogic 9 changes the Main Breaker Status contact (Out 5) and apply a trip signal via ProLogic 4. Reset occurs when ProLogic 2 (Breaker Status Reset) is activated.

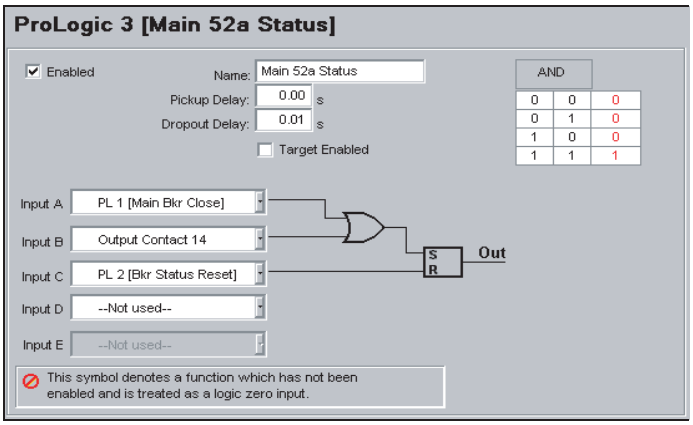

ProLogic 3 [Main 52a Status]
Enabled
Name: Main 52a Status
Pickup Delay: 0.00 s
Dropout Delay: 0.01 s
Target Enabled
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A PL 1 [Main Bkr Close]
Input B Output Contact 14
Input C PL 2 [Bkr Status Reset]
Input D --Not used--
Input E --Not used--
S
R
Out
This symbol denotes a function which has not been enabled and is treated as a logic zero input.

Figure 7.36: Main Breaker Status

ProLogic 4: This equation applies the External Trip (Closes Out 7), 10 seconds after the Breaker Status (ProLogic 3) goes high (i.e. Main Breaker Status = Closed).

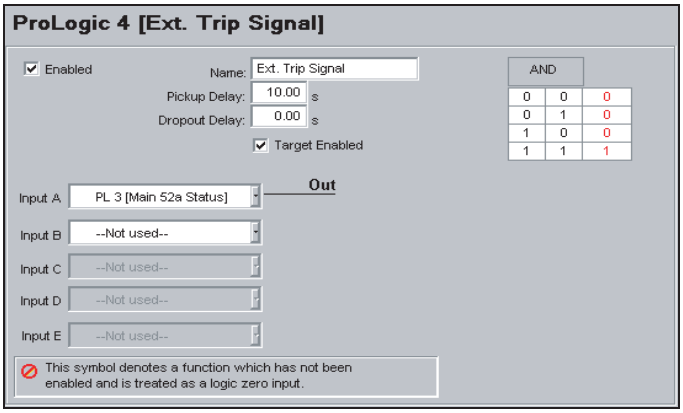

ProLogic 4 [Ext. Trip Signal]
Enabled
Name: Ext. Trip Signal
Pickup Delay: 10.00 s
Dropout Delay: 0.00 s
Target Enabled
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A PL 3 [Main 52a Status]
Input B --Not used--
Input C --Not used--
Input D --Not used--
Input E --Not used--
Out
This symbol denotes a function which has not been enabled and is treated as a logic zero input.

Figure 7.37: Using ProLogic to give Trip Command via External Input

ProLogic 5: This equation provides indication via the relay HMI display, that the Recloser has locked out.

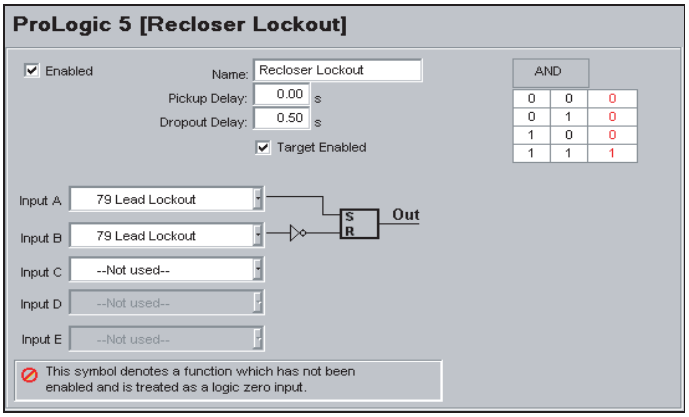


Figure 7.38: Recloser Lockout

ProLogic 6: This equation resets the 79 Lockout. It uses Virtual Input 1 “SCADA Reset 79" to simulate a SCADA Lockout Reset command. In this case, this is done by closing the Main Breaker Status (Out 5), then Auxiliary Breaker Status (Out 6) to simulate main and auxiliary breaker closed status. This latching function resets when the 79 Lead Lockout goes low.

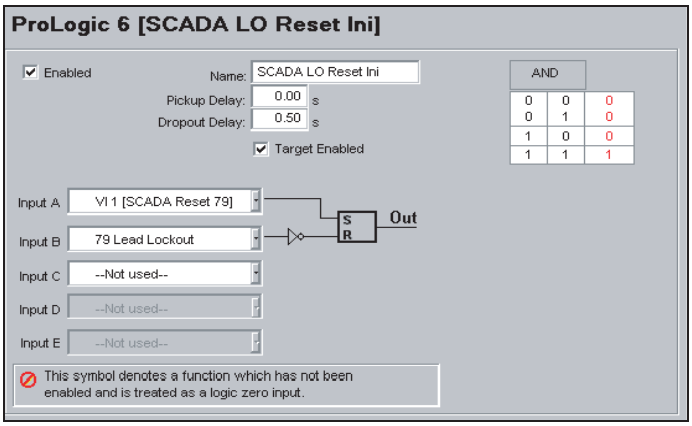

ProLogic 6 [SCADA LO Reset Ini]
Enabled
Name: SCADA LO Reset Ini
Pickup Delay: 0.00 s
Dropout Delay: 0.50 s
Target Enabled
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A VI 1 [SCADA Reset 79]
Input B 79 Lead Lockout
Input C --Not used--
Input D --Not used--
Input E --Not used--
S
R
Out
This symbol denotes a function which has not been enabled and is treated as a logic zero input.

Figure 7.39: Using Virtual Input to simulate SCADA Recloser Lockout Reset

ProLogic 7: This equation is intended only for giving indication of when the 79 Lockout is reset.

This indication, along with ProLogic 6, proves the 79 Reset timer (TD).

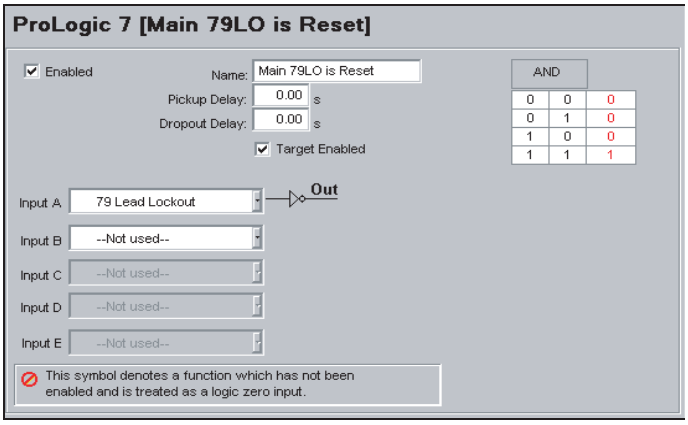

ProLogic 7 [Main 79LO is Reset]
Enabled
Name: Main 79LO is Reset
Pickup Delay: 0.00 s
Dropout Delay: 0.00 s
Target Enabled
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A 79 Lead Lockout
Input B --Not used--
Input C --Not used--
Input D --Not used--
Input E --Not used--
Out
This symbol denotes a function which has not been enabled and is treated as a logic zero input.

Figure 7.40: Main Recloser Lockout Reset Indication

ProLogic 8: This equation closes Out 6 to simulate auxiliary breaker closed status from SCADA breaker close command OR auxiliary recloser operation. This latching function resets when an external trip is received.

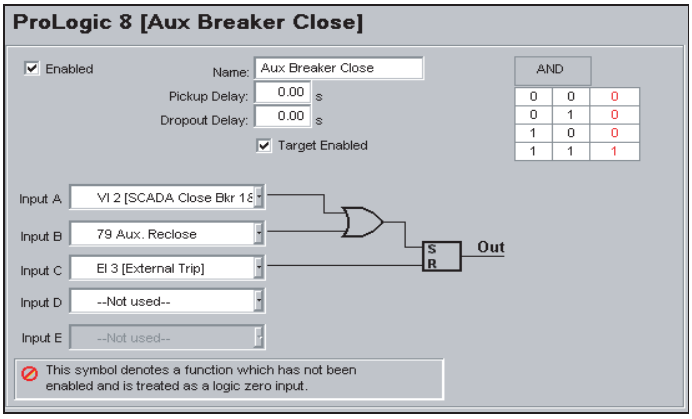

ProLogic 8 [Aux Breaker Close]
Enabled
Name: Aux Breaker Close
Pickup Delay: 0.00 s
Dropout Delay: 0.00 s
Target Enabled
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A VI 2 [SCADA Close Bkr 18
Input B 79 Aux. Reclose
Input C EI 3 [External Trip]
Input D --Not used--
Input E --Not used--
S
R
Out
This symbol denotes a function which has not been enabled and is treated as a logic zero input.

Figure 7.41: Auxiliary Breaker Close Command via Virtual Input

ProLogic 9: This equation closes Out 5 to simulate Main Breaker "a" contact, and also closes Out 14 to provide feedback into Main Breaker Status ProLogic 3. This latching function resets when an external trip is received.

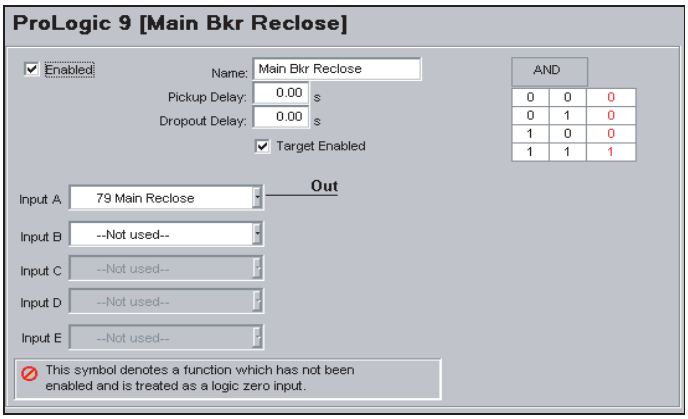

ProLogic 9 [Main Bkr Reclose]
Enabled
Name: Main Bkr Reclose
Pickup Delay: 0.00 s
Dropout Delay: 0.00 s
Target Enabled
AND
0 0 0
0 1 0
1 0 0
1 1 1
Out
Input A 79 Main Reclose
Input B --Not used--
Input C --Not used--
Input D --Not used--
Input E --Not used--
This symbol denotes a function which has not been enabled and is treated as a logic zero input.

Figure 7.42: Main Breaker Reclose

79 Reset Procedure (perform this before beginning the 79 Test)

1. In Relay Control Panel Service level access *Utilities>Virtual Inputs.*
2. Select Virtual Input 1 ("SCADA LO Reset Ini").
3. Pulse On (This simulates a "SCADA 79 Lockout Reset Command".)
   Observe the relay Target: "Init LO Reset VI: PL6"
   After 12 Seconds, Target: "Main LO is Reset: PL7"

End of 79 Reset procedure.

79 Test Procedure:

1. Access *Utilities>Virtual Inputs.*
2. Select Virtual Input 2 ("SCADA Close Breaker 1&2").
3. Pulse On (This simulates a SCADA Breaker Close command.)
   Observe the relay actions on the relay HMI:
   Main Breaker Close and Aux Breaker Close
   After 10 Seconds: External Trip (Time delay of ProLogic4)
   After 2 Seconds: Main Breaker Reclose (Shot 1, T1)
   After 8 Seconds: Auxiliary Breaker Close (Shot 1, TF)
   After 2 Seconds: External Trip (PL4 – TF)
   After 4 Seconds: Main Breaker Reclose (Shot 2, T2)
   After 8 Seconds: Aux Breaker Close (Shot 2, TF)
   After 2 Seconds: External Trip (PL4 – TF)
   After 6 Seconds: Main Breaker Reclose (Shot 3, T3)
   After 8 Seconds: Aux Breaker Close (Shot 3, TF)
   After 2 Seconds: External Trip (PL4 – TF)
   After 8 Seconds: Main Breaker Reclose (Shot 4, T4)
   After 8 Seconds: Aux Breaker Close (Shot 4, TF)
   After 2 Seconds: External Trip (PL4 – TF)
   After 1.3 Seconds: Recloser Lockout (1.0 seconds + Tp)
4. For detail of shot numbers, etc. observe the sequence of events by viewing *Main Menu>Events*
5. To perform this test again, reset the Lockout as per 79 Reset Procedure above, then repeat the 79 test procedure.

End of 79 test.

8 Installation

8.1 Introduction

This section deals with the installation of the L-PRO relay when first delivered. The section covers the physical mounting, AC and DC wiring and the Communication wiring.

8.2 Physical Mounting

Standard 3U

The relay is 3 rack units or 5.25 inches high and approximately 12.9 inches deep. The standard relay is designed for a 19-inch rack. A complete mechanical drawing is shown, for details see “Mechanical Drawings” in Appendix G

To install the relay the following is needed:

- 19 inch rack
- 4 - #10 screws

4U

The relay is 4 rack units or 7.0 inches high and approximately 12.25 inches deep. The relay is designed for a 19-inch rack. A complete mechanical drawing is shown, for details see “Mechanical Drawings” in Appendix G.

To install the relay the following is needed:

- 19 inch rack
- 4 - #10 screws

8.3 AC and DC Wiring

For details see “AC Schematic Drawings” in Appendix I and “DC Schematic Drawings” in Appendix J.

8.4 Communication Wiring

EIA-232

The relay’s serial ports (Ports 122 and 123) are configured as EIA RS-232 Data Communications Equipment (DCE) devices with female DB9 connectors. This allows them to be connected directly to a PC serial port with a standard straight-through male-to-female serial cable. Shielded cable is recommended, for pin-out see “Communication Port Details” on page 2-15.

An adapter is available for connecting an external modem to Port 123 for details see “Modem Link” on page 2-7.

RJ-45

There is one front 100BASE-T Ethernet Port 119 with RJ-45 receptacle. Use CAT5 or CAT5e straight. The rear Ethernet Ports 119 and 120 may also be configured as 100BASE-T Ethernet Ports.

Optical ST

Port 119 and port 120 in the rear panel may be configured with ST style optical connectors if desired. These are 1300 nm 100BASE-FX optical Ethernet ports. The transmit and receive connections are indicated on the rear panel. Use standard multi-mode cables with ST connectors for this interface.

USB

There is a standard USB-B connector on the front panel. This is a USB 2.0 Full Speed interface and can be connected to a PC with a standard USB peripheral cable (A style to B style).

RJ-11

The relay may have an optional internal modem. Connection to this is via the relay's Port 118 RJ-11 receptacle. A standard telephone extension cable is to be used.

IRIG-B Wiring

The relay accepts both modulated and unmodulated IRIG-B standard time signals with or without the IEEE 1344 extensions. The IRIG-B connector on the back of the relay is BNC type.

Appendix A IED Specifications

L-PRO Model 4000 Specifications

Item	Quantity/Specs	Note
General:		
Nominal Frequency	50 or 60 Hz	
Operate Time	1.0 to 1.3 cycles at 80% reach	Including output relay operation
Power Supply	43 – 275 Vdc, 90 – 265 Vac	Power Consumption: 25 – 30 VA (ac) 25 – 30 W (dc)
Memory	Settings and records are stored in non-volatile memory	Records are stored in a circular buffer
Protection Functions:		
IEEE Dev. 21P-1, 2, 3, 4,5, 21N-1, 2, 3, 4,5, 27, 50BF, 50LS, 50/51/67, 50N/ 51N/67, 46/50//51/67, 59,59N, 60, 68, 79-1, 3, Sync Check, 81, Switch-On-To-Fault, 60CTS, Weak Infeed, Mutual compensation, virtual inputs	2 x 3-phase voltage inputs for synchronizing during reclosing 2 x3-phase current inputs for protection Extra 6 currents used for recording and Pro-Logic input	Suitable for ring bus configurations and integrated HV breaker auto-recloser
ProLogic	24 statements per setting group	5 inputs per ProLogic^{TM} statement
Group Logic	8 (16 group logic statements per setting group)	5 inputs per group logic statement
Recording:		
Transient (Fault)	96 s/c oscillography of all analog and external input channels	User-configurable 0.2 to 10.0 seconds Record length and 0.1 to 2 seconds prefault length
Dynamic Swing	1 s/c phasor measurements of line positive sequence V and I plus frequency	User-configurable 60 – 120 seconds. Pre trigger time fixed at 30secs
Events	250 events circular log with 1ms resolution	When event auto save is enabled, a compressed event record is created every 250 events.
Record Capacity	75 records of a combination of transient, swing and optionally event records	

L-PRO Model 4000 Specifications

Input & Output:		
Analog Voltage Inputs 2 sets of 3-phase voltage inputs (6 voltage channels total)	Nominal Voltage - across input channel Full Scale/Continuous Maximum Over-scale Thermal Rating Burden	Vn = 69 Vrms (120 Vrms L-L) 2x Vn = 138 Vrms (240 Vrms L-L) 4x Vn = 276 Vrms (480 Vrms L-L) for 3 seconds 3x Vn = 207 Vrms (360 Vrms L-L) for 10 seconds <0.03VA @ Vn
Analog Current Inputs 4 sets of 3-phase current inputs (12 current channels)	Nominal Current Full Scale/Continuous Maximum full-scale rating Thermal rating Burden	In = 1 Arms or 5 Arms 3x In = 3 Arms or 15 Arms 40x In for 1 second symmetrical 400 Arms for 1 second <0.25 VA @ 5 Arms
Amplitude measurement accuracy	+/-0.5% for 54 to 66 Hz +/-0.5% for 44 to 56 Hz	
Analog Sampling Rate	96 samples/cycle for recording 8 samples/cycle for protection	Records up to 25th harmonic
External Inputs	9 isolated inputs (3U chassis) 20 isolated inputs (4U chassis)	Optional 48, 110/125 or 220/250 Vdc nominal, externally wetted
Isolation	2 KV optical isolation	
External Input Turn-on Voltage	48 Vdc range = 27 to 40 Vdc 125 Vdc = 75 to 100 Vdc 250 Vdc = 150 to 200 Vdc, 0% to 80% of nominal	Specified voltages are over full ambient temperature range.
Output Relays (contacts)		Externally wetted
Normal Contacts	3U: 14 programmable normal outputs and 1 relay inoperative normal output (normally closed) 4U: 21 programmable normal outputs and 1 relay inoperative normal output (normally closed)	Make: 30 A as per IEEE C37.90 Carry: 8 A Break: 0.9 A at 125 Vdc resistive 0.35 A at 250 Vdc resistive
HCFI Contacts	3U: 6 programmable normal outputs, 4 programmable HCFI outputs and 1 relay inoperative normal output (normally closed) 3U: 13 programmable normal outputs, 4 programmable HCFI outputs and 1 relay inoperative normal output (normally closed)	Make: 50A inductive (L/R=20ms). Carry: 6 A Break: 10.0 A L/R = 40 ms at 48Vdc 10.0 A L/R = 40 ms at 125 Vdc 10.0 A L/R = 20 ms at 250 Vdc
Virtual Inputs	30 Virtual Inputs	
Interface & Communication:		
Front Display	240 x128 pixels graphics LCD	
Front Panel Indicators	16 LEDs: 11 programmable, 5 fixed	Fixed: Relay Functional, IRIG-B Functional, Service Required, Test Mode, Alarm Target (11 programmable)
Front User Interface	USB port and 100BASE-T Ethernet port	Full Speed USB 2.0, RJ-45

L-PRO Model 4000 Specifications

Rear User Interface	LAN Port 1: 100BASE Copper or Optical 1300nm LAN Port 2: 100BASE Copper or Optical Two Serial RS-232 ports to 115 kbd modem	Copper: RJ-45, 100BASE-T Optical: 100BASE-FX, Multimode ST style connector Com port can support external modem
Internal Modem	33.6 Kbps, V.32 bis	Optional internal modem
SCADA Interface	IEC61850 (Ethernet) or DNP3 (RS-232 or Ethernet) or Modbus (RS-232)	Rear port
Time Sync	IRIG-B, BNC connector B003,B004,B123 and B124 Time Codes	Modulated or unmodulated, auto-detect
Self Checking/Relay Inoperative	1 contact	Closed when relay inoperative
Environmental:		
Ambient Temperature Range	-40°C to 85°C for 16 hours -40°C to 70°C continuous	IEC 60068-2-1/IEC 60068-2-2 LCD contrast impaired for temperatures below -20°C and above 70° C
Humidity	Up to 95% without condensation	IEC 60068-2-30
Insulation Test (Hi-Pot)	Power supply, analog inputs, external inputs, output contacts – 2 kVrms, 50/60 Hz, 1 minute	IEC 60255-5, ANSI/IEEE C37.90
Electrical Fast Transient	Tested to level 4 - 4.0 kV 2.5/5 kHz on Power and I/O lines	ANSI/IEEE C37.90.1, IEC/EN 60255-22-4, IEC 61000-4-4
Oscillatory Transient	Test level = 2.5kV	ANSI/IEEE C37.90.1, IEC/EN 60255-22-1, IEC61000-4-12 Level 3
RFI Susceptibility	10 V/m modulated, 35 V/m unmodulated	ANSI/IEEE C37.90.2, IEC 60255-22-3, IEC 61000-4-3 Level 3
Conducted RF Immunity	150 kHz to 80 MHz	IEC 60255-22-6 / IEC 61000-4-6 Level 3
Shock and Bump	5 g and 15 g	IEC 60255-21-2, IEC/EN 60068-2-27: Class 1
Sinusoidal Vibration	1 g, 10 Hz to 150 Hz, 1.0 octave/min, 40 sweeps	IEC/EN 60255-21-1, IEC/EN 60068-26, Class 1
Voltage Interruptions	200 ms interrupt	IEC 60255-11 / IEC 61000-4-11
Physical:		
Weight	3U chassis - 10.3 kg/22.6 lbs 4U chassis - 11.9 kg /26.2 lbs	
Dimensions	3U chassis: 13.2 cm height x 48.26 cm width rack mount x 32.8 cm depth 4U chassis 17.7 cm x 48.3 cm x 32.8 cm	5.2 height x 19 width rack mount x 12.9 depth 6.93" x 19 x 12.9
Time Synchronization and Accuracy		

L-PRO Model 4000 Specifications		
External Time Source	Synchronized using IRIG-B input (modulated or unmodulated) auto detect	Upon the loss of an external time source, the relay maintains time with a maximum 160 seconds drift per year at a constant temperature of 25C. The relay can detect loss of re-establishment of external time source and automatically switch between internal and external time.
Synchronization Accuracy	Sampling clocks synchronized with the time source (internal or external)	

L-PRO Model 4000 Specifications

Overall L-PRO Accuracies	
Current	±2.5% of inputs from 0.1 to 1.0 x nominal current (I_n)
	± 1.0% of inputs from 1.0 to 40.0 x nominal current (I_n)
Voltage	± 1.0% of inputs from 0.01 to 2.0 x nominal voltage (V_n)
Impedance	±5.0% or 5 mΩ of set value from 0.05 to 66.00 ohms secondary (0.25 to 330.00 ohms secondary, 1 A nominal)
Directional Phase Angle	±2.0° of set value of Positive Sequence Line Angle value from 25.0° to 89.0°
Frequency Elements	±0.001 Hz (fixed level)
	±0.05 Hz (df/dt)
Sync Check Elements	±0.2 degrees
Timers	±3 ms of set value
Inverse Overcurrent Timers	±2.5% or ±1 cycle of selected curve
Definite Overcurrent Timers	±2.5% or ±1 cycle non-directional
	±2.5% or ±1.5 cycle directional
Frequency Timer	±2.5% of set value plus 1.25 cycles to 1.75 cycles of inherent delay (fixed level) at 2x pickup, error <40 ms (df/dt) at 0.1 Hz/s above pickup, error <100 ms

L-PRO Model 4000 Specifications

Detailed Environmental Tests

Test	Description		Test Level
	Type Test	Test Points	
FCC Part 15	RF emissions	Enclosure ports	Class A: 30 - 1000 MHz
	Conducted emissions	ac/dc power ports	Class A: 0.15 - 30 MHz
IEC/EN 60255-25	RF emissions	Enclosure ports	Class A: 30 - 1000 MHz
	Conducted emissions	ac/dc power ports	Class A: 0.15 - 30 MHz
IEC/EN 61000-3-2	Power line harmonics	ac power port	Class D: max.1.08, 2.3, 0.431.14, 0.3, 0.77, 0.23 A.... for 2nd to nth harmonic
IEC/EN 61000-3-3	Power line fluctuations	ac power port	THD/ 3%; Pst <1., Plt < 0.65
		dc power port	N/A
IEC/EN 61000-4-2	ESD	Enclosure contact	+/- 6 kV
IEC/EN 60255-22-2		Enclosure air	+/- 8 kV
IEEE C37.90.3	ESD	Enclosure contact	+/- 8 kV
		Enclosure air	+/- 15 kV
IEC/EN 61000-4-3	Radiated RFI	Enclosure ports	10 V/m: 80 - 1000 MHz
IEC/EN 60255-22-3			
IEEE C37.90.2	Radiated RFI	Enclosure ports	35 V/m: 25 - 1000 MHz
IEC/EN 61000-4-4	Burst (fast transient)	Signal ports	+/- 4 kV @2.5 kHz
IEC/EN 60255-22-4		ac power port	+/- 4 kV
IEEE C37.90.1		dc power port	+/- 4 kV
		Earth ground ports	+/- 4 kV
IEC/EN 61000-4-5	Surge	Communication ports	+/- 1 kV L-PE
IEC/EN 60255-22-5		Signal ports	+/- 4 kV L-PE, +/-2 kV L-L
		ac power port	+/- 4 kV L-PE, +/-2 kV L-L
		dc power port	+/- 4 kV L-PE, +/-2 kV L-L
IEC/EN 61000-4-6	Induced (conducted) RFI	Signal ports	10 Vrms: 0.150 - 80 MHz
IEC/EN 60255-22-6		ac power port	10 Vrms: 0.150 - 80 MHz
		dc power port	10 Vrms: 0.150 - 80 MHz
		Earth ground ports	10 Vrms: 0.150 - 80 MHz
IEC/EN 60255-22-7	Power frequency	Binary input ports: Class A	Differential = 150 Vrms
			Common = 300 Vrms

L-PRO Model 4000 Specifications

Detailed Environmental Tests

IEC/EN 61000-4-8	Magnetic leld	Enclosure ports	40 A/m continuous, 1000 A/m for 1 s
IEC/EN 61000-4-11	Voltage dips & interrupts	ac power port	30% for 1 period, 60% for 50 periods
			100% for 5 periods, 100% for 50 periods
		dc power port	30% for 0.1 s, 60% for 0.1 s,
			100% for 0.05 s
IEC 60255-11	Voltage dips & interrupts	dc power port	100% reduction for up to 200 ms
IEC/EN 61000-4-12	Damped oscillatory	Communication ports	1.0 kV Common, 0 kV Diff
IEC/EN 60255-22-1		Signal ports	2.5 kV Common, 1 kV Diff
		ac power port	2.5 kV Common, 1 kV Diff
		dc power port	2.5 kV Common, 1 kV Diff
IEEE C37.90.1	Oscillatory	Signal ports	2.5 kV Common, 0 kV Diff
		ac power port	2.5 kV Common, 0 kV Diff
		dc power port	2.5 kV Common, 0 kV Diff
IEC/EN 61000-4-16	Mains frequency voltage	Signal ports	30 V continuous, 300 V for 1s
		ac power port	30 V continuous, 300 V for 1s
IEC/EN 61000-4-17	Ripple on dc power supply	dc power port	10%
Note:The L-PRO 4000 is available with 5 or 1 amp current input. All current specifications change accordingly.			

A.1 Distance Element Operating Time Curves at Nominal Frequency

Figure A.1 through A.6 show operating times for the relay distance elements.

The diagrams show operating times at each test point including output contact operate time.

Faults were applied at a location representing a percentage of the Zone 1 relay reach setting.

Tests were performed for source impedance ratios (SIR) of 0.1, 1.0, 10.0, and 30.0.

No pre-trigger load current or fault resistance was included. Operating times are the same for both 50 Hz and 60 Hz.

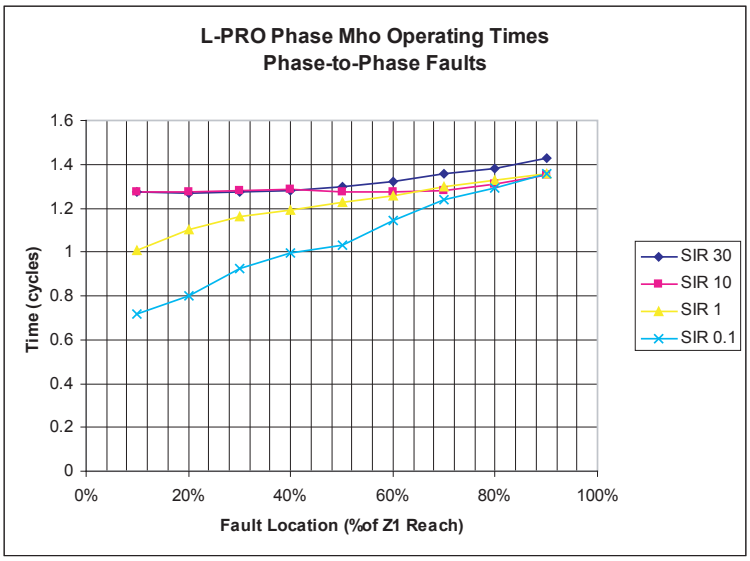


Figure A.1: Phase Mho Operating Times Phase-to-Phase Faults

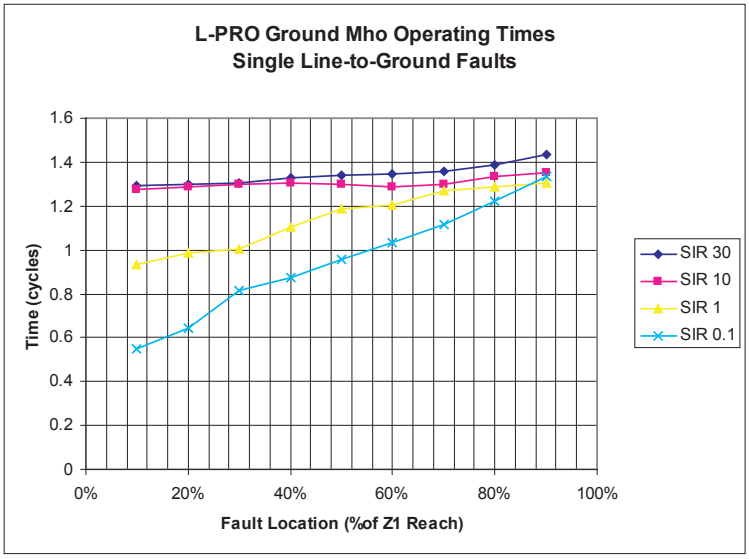


Figure A.2: Ground Mho Operating Times Single Line -to-Ground Faults

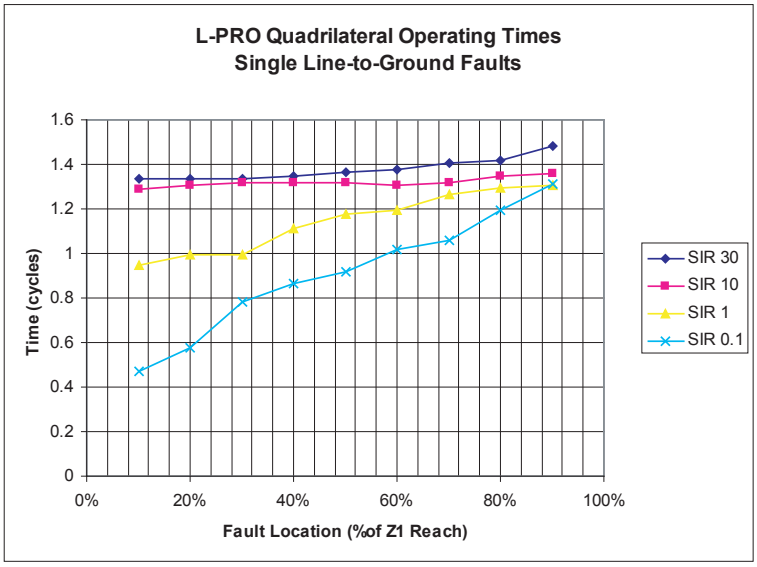


Figure A.3: Quadrilateral Operating Times Single Line-to-Ground Faults

A.2 Frequency Element Operating Time Curves

Figure A.4: Time delay Error at 0.2 seconds, Figure A.5: Time Delay Error at 1 second and Figure A.6: Time Delay Error at 10 seconds show operating times for the relay frequency rate of change elements at different time delay settings and rate of change settings.

The diagrams show operating times at each test point including output contact operate time. Operating times are the same for both 50 Hz and 60 Hz.

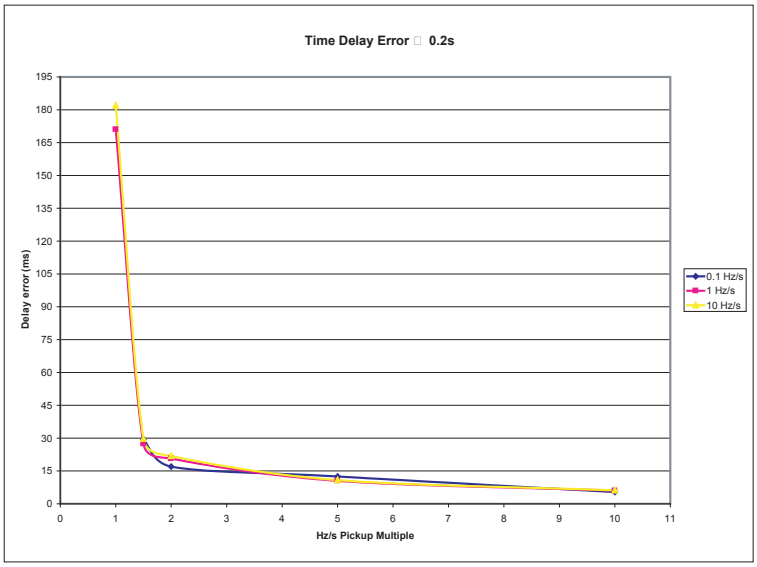


Figure A.4: Time delay Error at 0.2 seconds

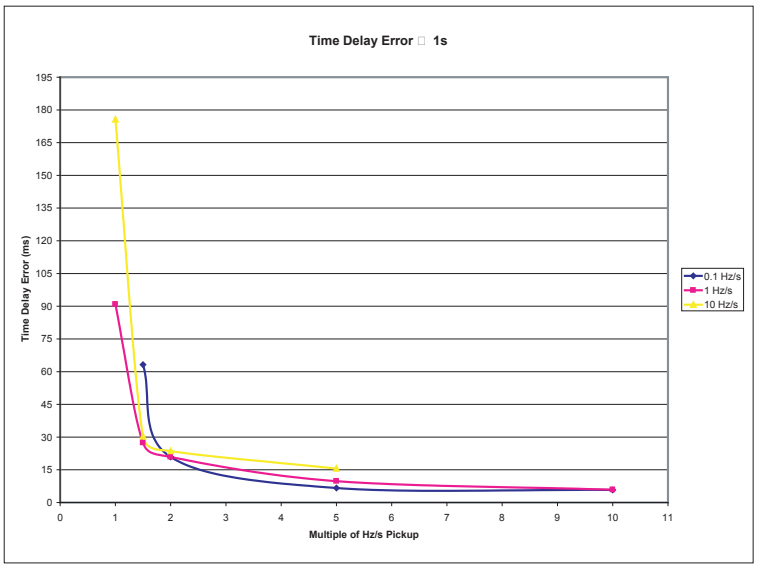


Figure A.5: Time Delay Error at 1 second

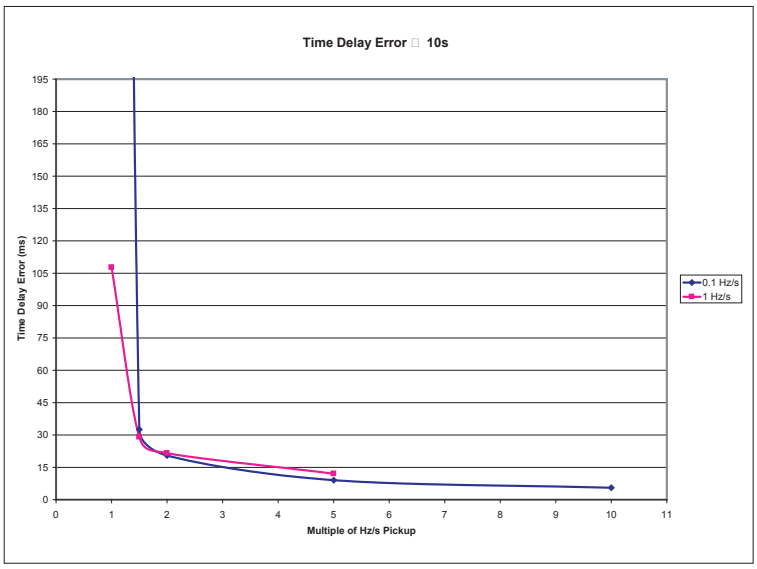


Figure A.6: Time Delay Error at 10 seconds

A.3 External Input Pickup Filter

To guarantee security from spurious voltage pulses an external input pickup filter setting has been introduced. This setting is made in Relay Control Panel under, *Utilities>Setup>External Inputs*. The setting is an integer number representing the number of samples in a packet of 12 that must be recognized by the DSP as high before an External Input status is changed from low to high. This will affect the pulse width required for the External Inputs to be detected. Below is a table describing the pulse widths for possible and definite defection for each setting.

Pickup Filter Count	Input Pulse Width required for EI to be possibly detected	Input Pulse Width required for EI to be definitely detected
4	0.694 ms	1.215 ms
5	0.868 ms	1.563 ms
6	1.042 ms	1.909 ms
7	1.215 ms	2.257 ms
8	1.389 ms	2.604 ms
9	1.563 ms	2.951 ms
10	1.736 ms	3.299 ms
11	1.909 ms	3.645 ms
12	2.083 ms	3.993 ms

For a setting of 6, it will take between 1.042 and 1.909 ms for an External Input to be declared as high. The default setting is 4.

Appendix B IED Settings and Ranges

B.1 Settings and Ranges

The Offliner software provides a means for the user to view and print a compact summary of the settings defined in each Setting Group, for a given device. The user can view the summary by selecting the Settings Summary option (last item) under each Setting Group listed in the Offliner application.

The summary includes general data from the Relay Identification screen, as well as all the user-defined names of inputs (e.g. current, voltage, virtual) and control outputs, and Group Logic definitions. It also includes all the user-defined settings along with their respective units and permissible value range.

The following pages illustrate the Settings Summary for Settings Group 1.

L-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Relay Identification			
Settings Version	407		
Ignore Serial Number	No		
Serial Number	LPRO-4000-000000-01		
Unit ID	UnitID		
Setting Name	Default Settings		
Nominal CT Secondary Current	5 A		
Nominal System Frequency	60 Hz		
Standard I/O	9 External Inputs, 14 Output Contacts		
Optional I/O	Not Installed		
Network Card	Installed		
Comments	Comments		
Date Created-Modified	2014-12-12 15:26:16		
Station Name	Station Name		
Station Number	1		
Location	Location		
Line	D245		
Analog Input Names			
LVA	Main Voltage A		
LVB	Main Voltage B		
LVC	Main Voltage C		
LIA	Main Line Current A		

LIB	Main Line Current B		
LIC	Main Line Current C		
IA2	Aux. Line Current A		
IB2	Aux. Line Current B		
IC2	Aux. Line Current C		
IA3	Current 3 A		
IB3	Current 3 B		
IC3	Current 3 C		
IA4	Current 4 A		
IB4	Current 4 B		
IC4	Current 4 C		
BVA	Aux. Voltage A		
BVB	Aux. Voltage B		
BVC	Aux. Voltage C		
External Input Names			
1	EI Spare 1		
2	EI Spare 2		
3	EI Spare 3		
4	EI Spare 4		
5	EI Spare 5		
6	EI Spare 6		
7	EI Spare 7		
8	EI Spare 8		
9	EI Spare 9		
Output Contact Names			
Output 1	Out Spare 1		
Output 2	Out Spare 2		
Output 3	Out Spare 3		
Output 4	Out Spare 4		
Output 5	Out Spare 5		
Output 6	Out Spare 6		
Output 7	Out Spare 7		
Output 8	Out Spare 8		
Output 9	Out Spare 9		
Output 10	Out Spare 10		
Output 11	Out Spare 11		
Output 12	Out Spare 12		
Output 13	Out Spare 13		
Output 14	Out Spare 14		
Output Contact Dropout Timers			

Output1 (Out Spare 1)	0.10	s	0.00 to 1.00
Output2 (Out Spare 2)	0.10	s	0.00 to 1.00
Output3 (Out Spare 3)	0.10	s	0.00 to 1.00
Output4 (Out Spare 4)	0.10	s	0.00 to 1.00
Output5 (Out Spare 5)	0.10	s	0.00 to 1.00
Output6 (Out Spare 6)	0.10	s	0.00 to 1.00
Output7 (Out Spare 7)	0.10	s	0.00 to 1.00
Output8 (Out Spare 8)	0.10	s	0.00 to 1.00
Output9 (Out Spare 9)	0.10	s	0.00 to 1.00
Output10 (Out Spare 10)	0.10	s	0.00 to 1.00
Output11 (Out Spare 11)	0.10	s	0.00 to 1.00
Output12 (Out Spare 12)	0.10	s	0.00 to 1.00
Output13 (Out Spare 13)	0.10	s	0.00 to 1.00
Output14 (Out Spare 14)	0.10	s	0.00 to 1.00
Virtual Input Names			
VI 1	Virtual Input 1		
VI 2	Virtual Input 2		
VI 3	Virtual Input 3		
VI 4	Virtual Input 4		
VI 5	Virtual Input 5		
VI 6	Virtual Input 6		
VI 7	Virtual Input 7		
VI 8	Virtual Input 8		
VI 9	Virtual Input 9		
VI 10	Virtual Input 10		
VI 11	Virtual Input 11		
VI 12	Virtual Input 12		
VI 13	Virtual Input 13		
VI 14	Virtual Input 14		
VI 15	Virtual Input 15		
VI 16	Virtual Input 16		
VI 17	Virtual Input 17		
VI 18	Virtual Input 18		
VI 19	Virtual Input 19		
VI 20	Virtual Input 20		
VI 21	Virtual Input 21		
VI 22	Virtual Input 22		
VI 23	Virtual Input 23		
VI 24	Virtual Input 24		
VI 25	Virtual Input 25		

VI 26	Virtual Input 26		
VI 27	Virtual Input 27		
VI 28	Virtual Input 28		
VI 29	Virtual Input 29		
VI 30	Virtual Input 30		
Setting Group Names			
Setting Group 1	Setting Group 1		
Setting Group 2	Setting Group 2		
Setting Group 3	Setting Group 3		
Setting Group 4	Setting Group 4		
Setting Group 5	Setting Group 5		
Setting Group 6	Setting Group 6		
Setting Group 7	Setting Group 7		
Setting Group 8	Setting Group 8		
System Parameters			
Base MVA	100.00	MVA	1.00 to 2000.00
Phase Rotation	ABC		
Aux Voltage Input	Three Phase		
Target Latching	Enabled		
Fault Location Display	Enabled		
Fault Location Initiated by 21 Alarm	Disabled		
Ring Bus Configuration (Aux CT Line Input)	Disabled		
Main CT Turns Ratio	240.00	:1 (Protection & Recording)	1.00 to 10000.00
Auxiliary CT Turns Ratio	300.00	:1 (Protection & Recording)	1.00 to 10000.00
CCVT Transient Compensation on All 21 Devices	Disabled		
Current Input #3 CT Ratio	400.00	:1 (For Mutual Compensation, Recording & ProLogic Input)	1.00 to 10000.00
Current Input #4 CT Ratio	500.00	:1 (For Mutual Compensation, Recording & ProLogic Input)	1.00 to 10000.00
Main PT Turns Ratio	2000.00	:1 (Protection & Recording)	1.00 to 20000.00
Auxiliary PT Turns Ratio	2000.00	:1 (Protection & Recording)	1.00 to 20000.00
Line to Line Voltage	230.00	kV Pri	1.00 to 2000.00
Distance Unit Selection	km		
Record Length			
Fault Record Length	0.5	s	0.2 to 10.0
Prefault Time	0.20	s	0.10 to 0.40

Swing Rcd. Length	120	s	60 to 120
Event Auto Save	Disabled		
Setting Group 1 [Setting Group 1]			
Setting Group Comments: Default settings			
Line Parameters			
Line Length	100.00	km	0.50 to 2000.00
Positive Sequence Impedance (Z1)	10.00	ohm	0.01 to 66.00
Positive Sequence Angle (Z1)	80.0	deg	5.0 to 89.0
Zero Sequence Impedance (Z0)	30.00	ohm	0.01 to 300.00
Zero Sequence Angle (Z0)	80.0	deg	5.0 to 89.0
Series Compensation	Disabled		
% Compensation	40.0	%	0.0 to 70.0
K0 Override	Disabled		
K0 Magnitude	0.67	-	0.00 to 10.00
K0 Angle	0.0	deg	-180.0 to 180.0
KM1 Mutual Line 1	Disabled		
KM1 Magnitude	1.00	-	0.10 to 2.00
KM1 Angle	0.0	deg	-25.0 to 25.0
KM2 Mutual Line 2	Disabled		
KM2 Magnitude	1.00	-	0.10 to 2.00
KM2 Angle	0.0	deg	-25.0 to 25.0
Scheme Selector			
Distance Scheme Selection	Basic		
Protection Scheme	3 Phase		
1Ph Max Open Pickup Delay (TM)	2.500	s	0.100 to 5.000
1Ph/3Ph for 3Ph Dropout Delay (TD4)	25.000	s	0.100 to 999.000
1Ph/3Ph for 1Ph Pickup Delay (TL5)	0.100	s	0.100 to 5.000
1Ph/3Ph for 1Ph Dropout Delay (TD5)	25.000	s	0.100 to 999.000
Fault Timer	Disabled		
Fault Timer Pickup	0.20	s	0.05 to 10.00
Communication Receiver1	EI 1 [EI Spare 1]		
Communication Receiver2	<disabled>		
Scheme Send Pickup Delay (TL3)	0.000	s	0.000 to 1.000
Scheme Send Dropout Delay (TD3)	0.100	s	0.000 to 1.000
POTT Current Reversal Pickup Delay (TL1)	0.000	s	0.000 to 0.500

POTT Current Reversal Dropout Delay (TD1)	0.100	s	0.000 to 0.500
DCB Scheme Zone 2 Pickup Delay (TL2)	0.050	s	0.005 to 0.500
DCB Scheme Receiver Dropout Delay (TD2)	0.100	s	0.000 to 0.500
DEF Scheme Selection	Disabled		
Communication Receiver3	<disabled>		
DEF Scheme Send Pickup Delay (TL6)	0.100	s	0.000 to 1.000
DEF Scheme Send Dropout Delay (TD6)	0.200	s	0.000 to 1.000
External Single Phase - Main A Phase	<disabled>		
External Single Phase - Main B Phase	<disabled>		
External Single Phase - Main C Phase	<disabled>		
External Three Phase - Main 3 Phase	<disabled>		
External Single Phase - Aux A Phase	<disabled>		
External Single Phase - Aux B Phase	<disabled>		
External Single Phase - Aux C Phase	<disabled>		
External Three Phase - Aux 3 Phase	<disabled>		
50N-67F - Overcurrent Carrier Trip			
Action	<diabled>		
Direction	Forward		
3I0 Pickup	1.0	A	0.2 to 50.0
Pickup Delay	0.020	s	0.005 to 99.990
50N-67R - Overcurrent Carrier Block			
Action	<diabled>		
Direction	Reverse		
3I0 Pickup	1.0	A	0.2 to 50.0
Pickup Delay	0.020	s	0.005 to 99.990
52 - Breaker Status			
Main Breaker	EI 3 [EI Spare 3]		
Aux. Breaker	<disabled>		
Directional Element			
Directional Element Override	Disabled		
Negative Seq. Directional Element	Enabled		
V2 Sensitivity Level	0.5	V	0.5 to 5.0
I2 Sensitivity Level	0.2	A	0.1 to 1.0

Zero Seq. Directional Element	Enabled		
3V0 Sensitivity Level	1.0	V	1.0 to 10.0
3I0 Sensitivity Level	0.2	A	0.2 to 2.0
Protection Summary			
21P, Zone 1	Disabled		
21P, Zone 2	Disabled		
21P, Zone 3	Disabled		
21P, Zone 4	Disabled		
21P, Zone 5	Disabled		
Load Encroachment	Disabled		
21N, Zone 1	Disabled		
21N, Zone 2	Disabled		
21N, Zone 3	Disabled		
21N, Zone 4	Disabled		
21N, Zone 5	Disabled		
68	Off		
Switch-On-To-Fault(SOTF)	Disabled		
Weak Infeed	Disabled		
25 Sync Check	Disabled		
Dead Main Live Aux (DMLA)	Disabled		
Live Main Dead Aux (LMDA)	Disabled		
Dead Main Dead Aux (DMDA)	Disabled		
79-3Ph	Disabled		
79-1Ph	Disabled		
59-1 Main	Disabled		
59-2 Main	Disabled		
59-1 Aux	Disabled		
59-2 Aux	Disabled		
59N Definite Time Delay	Disabled		
59N Inverse Time Delay	Disabled		
27 Main	Disabled		
27 Aux	Disabled		
60	Disabled		
60 CTS Main	Disabled		
60 CTS Aux	Disabled		
81-1	Disabled		
81-2	Disabled		
81-3	Disabled		
81-4	Disabled		
50LS Main (Input 1)	Disabled		

50LS Aux (Input 2)	Disabled		
50LS Input 3	Disabled		
50LS Input 4	Disabled		
50BF Main	Disabled		
50BF Aux	Disabled		
50	Disabled		
51	Disabled		
50N	Disabled		
51N	Disabled		
46-50	Disabled		
46-51	Disabled		
21P - Phase Distance: Zone 1			
21P - Zone 1	Disabled		
Type	Quadrilateral		
Forward Reach	8.00	ohm	0.00 to 66.00
Left Reach (R1)	10.00	ohm	0.05 to 66.00
Right Reach (R2)	10.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	0.00	s	0.00 to 99.99
Id Supervision	1.0	A	0.2 to 50.0
21P - Phase Distance: Zone 2			
21P - Zone 2	Disabled		
Type	Quadrilateral		
Forward Reach	12.00	ohm	0.00 to 66.00
Left Reach (R1)	15.00	ohm	0.05 to 66.00
Right Reach (R2)	15.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	0.50	s	0.00 to 99.99
Id Supervision	1.0	A	0.2 to 50.0
21P - Phase Distance: Zone 3			
21P - Zone 3	Disabled		
Type	Quadrilateral		
Forward Reach	15.00	ohm	0.00 to 66.00
Reverse Reach	0.00	ohm	0.00 to 66.00
Left Reach (R1)	15.00	ohm	0.05 to 66.00
Right Reach (R2)	15.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	1.50	s	0.00 to 99.99
Id Supervision	1.0	A	0.2 to 50.0
21P - Phase Distance: Zone 4			

21P - Zone 4	Disabled		
Type	Quadrilateral		
Forward Reach	0.00	ohm	0.00 to 66.00
Reverse Reach	2.00	ohm	0.00 to 66.00
Left Reach (R1)	5.00	ohm	0.05 to 66.00
Right Reach (R2)	5.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	1.50	s	0.00 to 99.99
Id Supervision	1.0	A	0.2 to 50.0
21P - Phase Distance: Zone 5			
21P - Zone 5	Disabled		
Type	Quadrilateral		
Forward Reach	20.00	ohm	0.00 to 66.00
Reverse Reach	0.00	ohm	0.00 to 66.00
Left Reach (R1)	15.00	ohm	0.05 to 66.00
Right Reach (R2)	15.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	1.50	s	0.00 to 99.99
Id Supervision	1.0	A	0.2 to 50.0
Load Impedance (common for 21N, 21P, and 68)			
Load Resistance (R)	20.0	ohm	-150.0 to 150.0
Load Reactance (X)	15.0	ohm	-150.0 to 150.0
Load Encroachment (common for 21P and 68)			
Load Encroachment	Disabled		
Impedance LHS	12.00	ohms secondary	0.01 to 66.00
Impedance RHS	12.00	ohms secondary	0.01 to 66.00
Upper Angle LHS	150.0	degrees	90.1 to 179.9
Upper Angle RHS	30.0	degrees	0.1 to 89.9
Lower Angle LHS	210.0	degrees	180.1 to 269.9
Lower Angle RHS	-30.0	degrees	-89.9 to -0.1
Tilt Angle (21P and 21N)			
21P - Phase Reactance Top Tilt Angle	-3.0	deg	-10.0 to 10.0
21N - Ground Reactance Top Tilt Angle	-3.0	deg	-10.0 to 10.0
21N - Ground Distance: Zone 1			
21N - Zone 1	Disabled		
Type	Quadrilateral		
Forward Reach	8.00	ohm	0.00 to 66.00

Left Reach (R1)	10.00	ohm	0.05 to 66.00
Right Reach (R2)	10.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	0.00	s	0.00 to 99.99
Ip Supervision	1.0	A	0.2 to 50.0
3I0 Supervision	1.0	A	0.2 to 50.0
21N - Ground Distance: Zone 2			
21N - Zone 2	Disabled		
Type	Quadrilateral		
Forward Reach	12.00	ohm	0.00 to 66.00
Left Reach (R1)	15.00	ohm	0.05 to 66.00
Right Reach (R2)	15.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	0.50	s	0.00 to 99.99
Ip Supervision	1.0	A	0.2 to 50.0
3I0 Supervision	1.0	A	0.2 to 50.0
21N - Ground Distance: Zone 3			
21N - Zone 3	Disabled		
Type	Quadrilateral		
Forward Reach	15.00	ohm	0.00 to 66.00
Reverse Reach	0.00	ohm	0.00 to 66.00
Left Reach (R1)	15.00	ohm	0.05 to 66.00
Right Reach (R2)	15.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	1.50	s	0.00 to 99.99
Ip Supervision	1.0	A	0.2 to 50.0
3I0 Supervision	1.0	A	0.2 to 50.0
21N - Ground Distance: Zone 4			
21N - Zone 4	Disabled		
Type	Quadrilateral		
Forward Reach	0.00	ohm	0.00 to 66.00
Reverse Reach	2.00	ohm	0.00 to 66.00
Left Reach (R1)	5.00	ohm	0.05 to 66.00
Right Reach (R2)	5.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	1.50	s	0.00 to 99.99
Ip Supervision	1.0	A	0.2 to 50.0
3I0 Supervision	1.0	A	0.2 to 50.0
21N - Ground Distance: Zone 5			
21N - Zone 5	Disabled		

Type	Quadrilateral		
Forward Reach	20.00	ohm	0.00 to 66.00
Reverse Reach	0.00	ohm	0.00 to 66.00
Left Reach (R1)	15.00	ohm	0.05 to 66.00
Right Reach (R2)	15.00	ohm	0.05 to 66.00
Mho Char. Angle	90.0	deg	70.0 to 140.0
Pickup Delay	1.50	s	0.00 to 99.99
Ip Supervision	1.0	A	0.2 to 50.0
3I0 Supervision	1.0	A	0.2 to 50.0
68 - Power Swing Block/Trip			
Mode	Off		
Zone 1 Blocking	Disabled		
Zone 2 Blocking	Disabled		
Zone 3 Blocking	Disabled		
Zone 4 Blocking	Disabled		
Zone 5 Blocking	Disabled		
Out of step Swing Timer	0.05	s	0.00 to 1.00
I1 Supervision	10.0	A	0.5 to 50.0
3Io Blocking	2.5	A	0.5 to 50.0
Blocking Reset Time	2.00	s	0.25 to 2.00
Top Blinder - Outer (X4)	27.0	ohm	18.0 to 100.0
Top Blinder - Inner (X3)	18.0	ohm	-18.0 to 27.0
Bottom Blinder - Inner (X2)	-18.0	ohm	-27.0 to 18.0
Bottom Blinder - Outer (X1)	-27.0	ohm	-100.0 to -18.0
LHS Blinder - Outer (R1)	-27.0	ohm	-100.0 to -18.0
LHS Blinder - Inner (R2)	-18.0	ohm	-27.0 to 18.0
RHS Blinder - Inner(R3)	18.0	ohm	-18.0 to 27.0
RHS Blinder - Outer(R4)	27.0	ohm	18.0 to 100.0
Switch-On-To-Fault(SOTF)			
Switch-On-To-Fault	Disabled		
Breaker Signal	Close Command		
Close Command Pulse	EI 1 [EI Spare 1]		
Main Breaker Status	EI 3 [EI Spare 3]		
Aux Breaker Status	<disabled>		
Pole Dead Pickup Timer	0.2	s	0.0 to 999.9
Enable Duration	0.2	s	0.0 to 999.9
Device 50 Pickup	10.0	A	0.5 to 50.0
Device 50N Pickup	2.5	A	0.1 to 50.0
Device 21 Zone-2	Disabled		

Undervoltage (27) Supervision	Disabled		
Device 27 Pickup	25.00	V	1.00 to 120.00
Second Harmonic Restraint	Enabled		
I2/I1 Ratio	0.2	-	0.0 to 10.0
Weak Infeed			
Weak Infeed	Disabled		
Device 27 V1 Pickup	51.0	V	0.0 to 69.0
Device 59 3V0 Pickup	5.0	V	0.0 to 100.0
Zone2/Zone4 Reset Delay (TWD1)	0.10	s	0.02 to 0.20
Comm. Cycle Reset Delay (TWD2)	0.05	s	0.02 to 0.20
Comm. Reset Time Delay (TWD3)	0.15	s	0.02 to 1.00
25/27/59 - Sync Check			
25 Sync Check	Disabled		
Maximum Voltage	70.0	V	60.0 to 138.0
Minimum Voltage	40.0	V	40.0 to 69.9
Angle Difference	20.0	deg	1.0 to 50.0
Pickup Delay	0.10	s	0.00 to 10.00
Frequency Difference	Disabled		
Frequency Difference	0.000	Hz	0.010 to 2.000
Dead Main Live Aux. (DMLA)	Disabled		
Live Main Dead Aux. (LMDA)	Disabled		
Dead Main Dead Aux. (DMDA)	Disabled		
79-3Ph - Recloser			
79-3Ph	Disabled		
Number of Shots	1		
First Reclose (T1)	1.0	s	0.1 to 999.9
Second Reclose (T2)	5.0	s	1.0 to 999.9
Third Reclose (T3)	10.0	s	1.0 to 999.9
Fourth Reclose (T4)	20.0	s	1.0 to 999.9
Close Time (Tp)	0.2	s	0.1 to 1.0
Lockout Reset (TD)	25.0	s	0.1 to 999.9
Initiate Reset (TDI)	0.1	s	0.0 to 999.9
Sync Control	Disabled		
Recloser Mode	Main Only		
Block Reset (TDB)	0.1	s	0.0 to 999.9
Follower Time (TF)	5.0	s	0.0 to 24.9
Breaker Out of Service (TC)	50.0	s	0.0 to 999.9
Follower Sequencer Switch	Close after the Recloser Follower Time (TF)		

79-1Ph - Recloser			
79-1Ph	Disabled		
Number of Shots	1		
Reclose (T1)	1.0	s	0.1 to 999.9
Close Time (Tp)	0.2	s	0.1 to 1.0
Lockout Reset (TD)	25.0	s	0.1 to 999.9
Initiate Reset (TDI)	0.1	s	0.0 to 999.9
Recloser Mode	Main Only		
Block Reset (TDB)	0.1	s	0.0 to 999.9
Follower Time (TF)	5.0	s	0.0 to 24.9
Breaker Out of Service (TC)	50.0	s	0.0 to 999.9
Follower Sequencer Switch	Close after the Recloser Follower Time (TF)		
59 - Overvoltage			
59-1 Main	Disabled		
Gate Switch	OR		
Pickup	70.0	V	1.0 to 138.0
Pickup Delay	5.00	s	0.00 to 10.00
59-2 Main	Disabled		
Gate Switch	OR		
Pickup	70.0	V	1.0 to 138.0
Pickup Delay	5.00	s	0.00 to 10.00
59-1 Aux	Disabled		
Gate Switch	OR		
Pickup	70.0	V	1.0 to 138.0
Pickup Delay	5.00	s	0.00 to 10.00
59-2 Aux	Disabled		
Gate Switch	OR		
Pickup	70.0	V	1.0 to 138.0
Pickup Delay	5.00	s	0.00 to 10.00
59N - Zero Sequence OverVoltage			
59N Inverse Time Delay	Disabled		
3V0 Pickup	10.00	V	5.00 to 150.00
Curve Type	IEC standard inverse		
TMS	1.00	-	0.01 to 10.00
A	0.14	-	-
B	0.0	-	-
p	0.02	-	-
TR	13.50	-	-
59N Definite Time Delay	Disabled		

Pickup	10.00	V	5.00 to 150.00
Pickup Delay	2.00	s	0.00 to 99.99
27 - Undervoltage			
27 Main	Disabled		
Gate Switch	AND		
Pickup	25.0	V	1.0 to 120.0
Pickup Delay	5.00	s	0.00 to 10.00
27 Auxiliary	Disabled		
Gate Switch	AND		
Pickup	25.0	V	1.0 to 120.0
Pickup Delay	5.00	s	0.00 to 10.00
60 - Loss Of Potential Alarm			
60	Disabled		
I1 Blocking	7.5	A	0.5 to 50.0
3I0 Blocking	1.0	A	0.5 to 50.0
Negative Sequence Monitoring	Disabled		
Vnps	10.0	V	7.0 to 110.0
Inps	0.50	A	0.25 to 5.00
60 CT Supervision			
60CTS Main	Disabled		
Inps Pickup	1.00	A	0.25 to 5.00
Vnps Pickup	7.00	V	7.00 to 110.00
Pickup Delay	2.00	s	0.03 to 99.99
60CTS Aux	Disabled		
Inps Pickup	1.00	A	0.25 to 5.00
Vnps Pickup	7.00	V	7.00 to 110.00
Pickup Delay	2.00	s	0.03 to 99.99
81 - Over/Under Frequency			
81-1	Disabled		
Pickup	57.600	Hz	[50.000, 59.995] or [60.005, 70.000]
Pickup Delay	2.00	s	0.05 to 99.99
81-2	Disabled		
Pickup	57.000	Hz	[50.000, 59.995] or [60.005, 70.000]
Pickup Delay	2.00	s	0.05 to 99.99
81-3	Disabled		

Pickup	61.800	Hz	[50.000, 59.995] or [60.005, 70.000]
Pickup Delay	2.00	s	0.05 to 99.99
81-4	Disabled		
Pickup	62.400	Hz	[50.000, 59.995] or [60.005, 70.000]
Pickup Delay	2.00	s	0.05 to 99.99
50LS - Low Set Overcurrent			
50LS Main (Input 1)	Disabled		
Pickup	50.00	A	0.10 to 50.00
Pickup Delay	1.00	s	0.00 to 10.00
50LS Auxiliary (Input 2)	Disabled		
Pickup	50.00	A	0.10 to 50.00
Pickup Delay	1.00	s	0.00 to 10.00
50LS Input 3	Disabled		
Pickup	50.00	A	0.10 to 50.00
Pickup Delay	1.00	s	0.00 to 10.00
50LS Input 4	Disabled		
Pickup	50.00	A	0.10 to 50.00
Pickup Delay	1.00	s	0.00 to 10.00
50BF - Breaker Failure			
50BF Main	Disabled		
Pickup Delay 1	0.20	s	0.01 to 99.99
Pickup Delay 2	0.20	s	0.01 to 99.99
Breaker Current Pickup	1.00	A	0.10 to 50.00
50BF Auxiliary	Disabled		
Pickup Delay 1	0.20	s	0.01 to 99.99
Pickup Delay 2	0.20	s	0.01 to 99.99
Breaker Current Pickup	1.00	A	0.10 to 50.00
50/51/67 - Phase Overcurrent			
50	Disabled		
Directional Control	forward		0: non-directional, 3: forward, 4: reverse
Pickup	50.00	A	0.50 to 150.00
Pickup Delay	1.00	s	0.01 to 99.99
51	Disabled		
Directional Control	forward		0: non-directional, 3: forward, 4: reverse

Pickup	7.50	A	0.25 to 25.00
Curve Type	IEC standard inverse		
TMS	1.00	-	0.01 to 10.00
A	0.14	-	-
B	0.0	-	-
p	0.02	-	-
TR	13.50	-	-
Directional Angle Setting	Disabled		
Alpha	0.00	-	-179.90 to 180.00
Beta	180.00	-	0.10 to 360.00
50 Pickup Current Multiplier	1.00	times setting	0.10 to 2.00
50 Pickup Time Multiplier	1.00	times setting	0.10 to 2.00
51 Pickup Current Multiplier	1.00	times setting	0.10 to 2.00
51 Pickup Time Multiplier	1.00	times setting	0.10 to 2.00
50N/51N/67 - Neutral Overcurrent			
50N	Disabled		
Directional Control	forward		0: non-directional, 3: forward, 4: reverse
Pickup	5.00	A	0.25 to 50.00
Pickup Delay	1.00	s	0.01 to 99.99
51N	Disabled		
Directional Control	forward		0: non-directional, 4: forward, 5: reverse, 6: forward & in scheme
Pickup	1.00	A	0.25 to 50.00
Curve Type	IEC standard inverse		
TMS	1.00	-	0.01 to 10.00
A	0.14	-	-
B	0.0	-	-
p	0.02	-	-
TR	13.50	-	-
Directional Angle Setting	Disabled		
Alpha	0.00	-	-179.90 to 180.00
Beta	180.00	-	0.10 to 360.00
50N Pickup Current Multiplier	1.00	times setting	0.10 to 2.00
50N Pickup Time Multiplier	1.00	times setting	0.10 to 2.00
51N Pickup Current Multiplier	1.00	times setting	0.10 to 2.00
51N Pickup Time Multiplier	1.00	times setting	0.10 to 2.00

46-50/46-51/67 - Negative Sequence Overcurrent			
46-50	Disabled		
Directional Control	forward		0: non-directional, 3: forward, 4: reverse
Pickup	2.50	A	0.50 to 50.00
Pickup Delay	1.00	s	0.01 to 99.99
46-51	Disabled		
Directional Control	forward		0: non-directional, 3: forward, 4: reverse
Pickup	1.00	A	0.50 to 50.00
Curve Type	IEC standard inverse		
TMS	1.00	-	0.01 to 10.00
A	0.14	-	-
B	0.0	-	-
p	0.02	-	-
TR	13.50	-	-
Directional Angle Setting	Disabled		
Alpha	0.00	-	-179.90 to 180.00
Beta	180.00	-	0.10 to 360.00
46-50 Pickup Current Multiplier	1.00	times setting	0.10 to 2.00
46-50 Pickup Time Multiplier	1.00	times setting	0.10 to 2.00
46-51 Pickup Current Multiplier	1.00	times setting	0.10 to 2.00
46-51 Pickup Time Multiplier	1.00	times setting	0.10 to 2.00
Z Circle Trigger			
Swing Trigger	Disabled		
Positive Seq. Impedance	20.0	ohm	0.1 to 50.0
ProLogic 1 [ProLogic 1]			
[ProLogic 1]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			

Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 2 [ProLogic 2]			
[ProLogic 2]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 3 [ProLogic 3]			
[ProLogic 3]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 4 [ProLogic 4]			
[ProLogic 4]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		

Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 5 [ProLogic 5]			
[ProLogic 5]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 6 [ProLogic 6]			
[ProLogic 6]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 7 [ProLogic 7]			
[ProLogic 7]	Disabled		

Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 8 [ProLogic 8]			
[ProLogic 8]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 9 [ProLogic 9]			
[ProLogic 9]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			

Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 10 [ProLogic 10]			
[ProLogic 10]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 11 [ProLogic 11]			
[ProLogic 11]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 12 [ProLogic 12]			
[ProLogic 12]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		

Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 13 [ProLogic 13]			
[ProLogic 13]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 14 [ProLogic 14]			
[ProLogic 14]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 15 [ProLogic 15]			
[ProLogic 15]	Disabled		

Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 16 [ProLogic 16]			
[ProLogic 16]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 17 [ProLogic 17]			
[ProLogic 17]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			

Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 18 [ProLogic 18]			
[ProLogic 18]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 19 [ProLogic 19]			
[ProLogic 19]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 20 [ProLogic 20]			
[ProLogic 20]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		

Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 21 [ProLogic 21]			
[ProLogic 21]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 22 [ProLogic 22]			
[ProLogic 22]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 23 [ProLogic 23]			
[ProLogic 23]	Disabled		

Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
ProLogic 24 [ProLogic 24]			
[ProLogic 24]	Disabled		
Pickup Delay	0.00	s	0.00 to 999.00
Dropout Delay	0.00	s	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 1 [Group Logic 1]			
[Group Logic 1]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		

Operator 5			
Input E	<Unused = 0>		
Group Logic 2 [Group Logic 2]			
[Group Logic 2]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 3 [Group Logic 3]			
[Group Logic 3]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 4 [Group Logic 4]			
[Group Logic 4]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		

Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 5 [Group Logic 5]			
[Group Logic 5]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 6 [Group Logic 6]			
[Group Logic 6]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 7 [Group Logic 7]			
[Group Logic 7]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		

Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 8 [Group Logic 8]			
[Group Logic 8]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 9 [Group Logic 9]			
[Group Logic 9]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 10 [Group Logic 10]			
[Group Logic 10]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		

Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 11 [Group Logic 11]			
[Group Logic 11]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 12 [Group Logic 12]			
[Group Logic 12]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 13 [Group Logic 13]			
[Group Logic 13]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999

Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 14 [Group Logic 14]			
[Group Logic 14]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 15 [Group Logic 15]			
[Group Logic 15]	Disabled		
Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 16 [Group Logic 16]			
[Group Logic 16]	Disabled		

Setting Group to Activate	none		
Pickup Delay	0	s	0 to 999
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		

Appendix C Hardware Description

The relay is a complete line distance protection relay package designed and manufactured with high quality features and recording components. The following information describes the main hardware components of the relay:

Main Processor Board (MPB)

The MPB has two processor sub-systems which control the operation of the entire relay: the DSP processor and the control processor. The DSP sub-system interfaces to the RAIB, the DIB and the OCB and manages the protection features of the relay. The control processor manages the user interface and system control features of the relay. Both subsystems operate independently of each other and will continue to function even if the other sub-system fails.

The MPB provides the following functionality:

- DSP processor subsystem which interfaces to the RAIB, the DIB and the OCB and manages the protection features of the relay, with:
  - The floating point DSP to provide fast capture and manipulation of data.
  - RAM and reprogrammable non-volatile Flash memory. Allows operation independent of the control processor and supports field software updates.
- A control processor subsystem which manages the user interface and system control features of the relay, with
  - RAM and reprogrammable non-volatile Flash memory. Allows operation independent of the DSP processor and supports field software upgrades.
  - Settings and recordings stored in non-volatile memory.
  - Runs a Real Time Operating System (RTOS).
  - Provides Ethernet ports and RS-232 ports for modem, SCADA, COM and USB interfaces.
- A time synchronism processor with automatic detection of modulated and un-modulated IRIG-B
- A high speed link is provided between the DSP and control processor subsystems.
- Sophisticated fault detection and “watchdog” recovery hardware
- The MPB also provides the power supply for the entire unit. The power supply operating range is 48-250 Vdc, 100-240 Vac, +/-10%, 50/60 Hz. This wide operating range provides easier installation by eliminating power supply ordering options

Digital Input Board (DIB)

This board provides 9 digital input channels. Inputs are optically isolated, externally wetted, and factory preset to the customer’s requested voltage level of 48, 110/125 or 220/250 Vdc. This board interfaces to the MPB.

Rear Panel Comm Board (RPCB)

The RPCB provides the relay with two RS-232 ports (Ports 122 and 123, DB9F), IRIG-B time synchronization input (Port 121, male BNC), internal modem connection (Port 118, RJ-11) and two Ethernet ports (Ports 119 and 120, RJ-45 or 100BASE-FX MM 1300nm ST, depending upon order specification). The RPCB interfaces to the MPB. Port 119 is the exception in that it interfaces to the GFPCB where it shares an internal switch with the front panel LAN port. The switch then interfaces to the MPB.

Output Contact Board (LOCB)

The LOCB provides 14 normally open contact outputs for relaying, alarms and control. It also provides one normally closed output contact for relay inoperative indication. This board interfaces to the MPB.

Output Contact Board (LOCBH)

The LOCBH provides the following output contacts for relaying, alarms and control:

- One normally closed relay inoperative indicator normal output contact
- 6 user-defined normal output contacts with both normally open and normally closed terminals made available to the user
- 4 user-defined high current fast interrupting (HCFI) output contacts

The LOCBH interfaces to the MPB.

Digital Input/ Output Board (DIGIO)

The DIGIO provides 11 digital input channels. Inputs are optically isolated, externally wetted, and factory preset to the customer's requested voltage level of 48, 110/125 or 220/250 Vdc. The DIGIO also provide 7 normally open contact outputs for relaying, alarms and control. This board interfaces to the MPB.

Relay AC Analog Sensor Boards (RASB)

Each relay has 3 RASBs. Two RASBs have 3 voltage transformer inputs and 3 current transformer inputs while the third RASB has 6 current transformer inputs. These boards provide 12 current and 6 voltage ac analog measurement inputs. The RASBs interface to the RAIB.

Relay AC Analog Input Board (RAIB)

The RAIB provides the analog to digital conversion of the 12 ac analog current inputs and the 6 ac analog voltage inputs. The sample rate is fixed at 96 samples/cycle. Each channel is simultaneously sampled using 16-bit analog to digital converters. The digitized data is sent to the MPB for processing and implementation of the protection algorithms.

Graphics Front Panel Comm Board (GFPCB)

The GFPCB provides the front panel USB and Ethernet ports, the front panel status LEDs and interfaces the MPB to the FPDB. The MPB controls the state of the LEDs.

Graphics Front Panel Display Board (GFPDB)

The GFPDB provides the 240x128 monochrome graphics front panel display and the keypad. The keypad is used to navigate the menus on the display to control relay operation by a local user.

Appendix D Event Messages

The following is a list of event messages that are created in the relay for events including trips, alarms, external input assertions, and internal events such as setting changes. This list is referred to from multiple places in this manual.

L-PRO Event Messages	
Event Log Message	**Notes**
21P1 ABC 12.3km:Trip 21P2 ABC 12.3km:Trip 21P3 ABC 12.3km:Trip 21P4 ABC 12.3km:Trip 21P5 ABC 12.3km:Trip	The possible phase information for 21P1–21P5 will be: • AB • BC • CA • AB, BC • AB, CA • CA, BC • ABC • ABG • BCG • CAG • ABGBC • BCGCA • CAGAB • ABCG
21N1 AG 12.3km:Trip 21N2 AG 12.3km:Trip 21N3 AG 12.3km:Trip 21N4 AG 12.3km:Trip 21N5 AG 12.3km:Trip	The possible phase information for 21N1–N5 will be: • AG • BG • CG • ABG • BCG • CAG • ABCG
21P2 ABC 12.3km:Alarm 21P3 ABC 12.3km:Alarm 21P4 ABC 12.3km:Alarm 21P5 ABC 12.3km:Alarm	The possible phase information for 21P2–21P5 will be: • AB • BC • CA • AB, BC • AB, CA • CA, BC • ABC • ABG • BCG • CAG • ABGBC • BCGCA • CAGAB • ABCG
21N2 AG 12.3km:Alarm 21N3 AG 12.3km:Alarm 21N4 AG 12.3km:Alarm 21N5 AG 12.3km:Alarm 51N AG 12.3km:Trip 50N AG 12.3km:Trip	The possible phase information for 21N2–N5 and 50N/51N will be: • AG • BG • CG • ABG • BCG • CAG • ABCG
46-51: Trip	
46-50: Trip	
51 ABC:Trip 50 ABC:Trip	The possible phase information will be: • A • B • C • AB • BC • CA • ABC
51N: Alarm	
46-51: Alarm	

L-PRO Event Messages	
51 ABC: Alarm	The possible phase information will be: • A • B • C • AB • BC • CA • ABC
Impedance Circle Trigger	
68 Power Swing: Trip	Trip or Block based on 68 mode setting
PUTT ABCG 12.3 km: Trip DCB ABCG 12.3 km: Trip POTT ABCG 12.3 km: Trip POTT (WI) ABCG 12.3 km: Trip	The possible phase information is • AG • BG • CG • ABG • BCG • CAG • AB • BC • CA • AB, BC • AB, CA • CA, BC • ABC • ABCG • ABGBC • BCGCA • CAGAB Weak Infeed (WI) is not available unless POTT is selected.
DEF: Trip	
59NDef: Trip	
59Ninv: Trip	
PUTT: ABCG Send POTT: ABCG Send POTT: (WI) ABCG Send DCB: ABCG Send	The possible phase information is • AG • BG • CG • ABG • BCG • CAG • ABCG Weak Infeed (WI) is not available unless POTT is selected.
DEF: Send	
SOTF ABC	The possible phase information for the Switch-On-To-Fault will be: • A • B • C • AB • BC • CA • ABC
ProLogic Name: PLn	ProLogic outputs names are user assigned
Extern Input Name: EIn: High	External Input names are user assigned
Extern Input Name: EIn: Low	External Input names are user assigned
Virtual Input Name: VIn: High	Virtual Input names are user assigned
Virtual Input Name: VIn: Low	Virtual Input names are user assigned
Output Contact Name: OCn: High	Output Contact names are user assigned
Output Contact Name: OCn: Low	Output Contacts names are user assigned
59N Def: Alarm	
59N Inv: Alarm	

L-PRO Event Messages	
60 LOP ABC: Alarm	The possible phase information will be: • A • B • C • AB • BC • CA • ABC
60 CTS Main: Alarm	
60 CTS Aux: Alarm	
Load Encroachment Block	
Success Reclose Main	
Success Reclose Aux	
68 Inner Blinder: Alarm	
68 Outer Blinder: Alarm	
Com-Aided (Z2,Wi): Send	Scheme types: WI, Z2, Z2 & WI, Z2 is Zone 2 POTT and WI is Weak Infeed
27 Main ABC: Trip	The possible phase information will be: • A • B • C • AB • BC • CA • ABC
27 Aux. ABC: Trip	
59-1 Main ABC: Trip	
59-2 Main ABC: Trip	
59-1 Aux. ABC: Trip	
59-2 Aux. ABC: Trip	
50LS Main ABC: Trip	
50LS Aux. ABC: Trip	
252759 Sync Check:	
50BF-1 Main ABC:Trip	The possible phase information will be: • A • B • C • AB • BC • CA • ABC
50BF-2 Main ABC:Trip	
50BF-1 Aux ABC:Trip	
50BF-2 Aux ABC:Trip	
81-1: Trip	
81-2: Trip	
81-3: Trip	
81-4: Trip	
79-3 Ph Initiated: High	Recloser is initiated.
79-3 Lead Lockout	Recloser shot count has expired and reclosing attempts are blocked.
79-3 Follow Lockout	Follow breaker has failed to reclose.
79-3 Main Reclose: shot n	Recloser Main circuit breaker close attempt where n equals the shot count.
79-3 Follow Reclose: shot n	Recloser Aux. circuit breaker close attempt where n equals the shot count.
79-3 Block: High	Recloser is blocked by an external signal.
50BF Initiate: High	

L-PRO Event Messages	
Self Check: DC Ch.n: Alarm	Continuous dc level on Ch. n, where n = 1 to 18.
Self Check: DC Alarm Reset	Continuous dc level, condition has reset.
Self Check: DC Ch.n: O/P Block	Continuous dc level on Ch. n, where n = 1 to 18. Relay is blocked.
New Settings loaded, Active group n.	Where n = 1-8
New Setting Loaded	
Manual Settings Load request, activate SGn	Manual or user-initiated settings change.
Manual Settings Load request completed	Completion of user-initiated settings change.
Changed Active Group from x to y Logic n	This happens when relay changes setting group. Automatic group logic initiated setting group change
User changed Active Group from x to y	This happens when the relay changes setting group. User initiated setting group change
Unit Recalibrated	
Unit restarted	
User logged In	

Note: For either of the above cases the DSP controller functions continue with normal auxiliary relay outputs provided that DSP failure or Self Check Fail: Block has not occurred.

Self Check Fail due to DC Offset Detector

The DSP has an algorithm that detects continuous dc levels on the analog inputs and initiates alarms and relay output contact blocking when the measured dc level exceeds the Alarm or Block level. The Alarm level is intended to provide an early indication of a problem. The Block level blocks the relay from false-tripping by preventing any output contact from closing. The Relay Functional LED turns off, but the protection functions will operate normally, with the exception that the output contacts will not be allowed to close. The Relay Inoperative contact will close for a Block condition. The following table describes all the Alarm/Block indication functions

Action	Condition	
	Alarm	Block
Relay Functional LED off		X
Service Required LED on	X	X
Self Check Fail Signal high	X	X
Relay Inoperative Contact closed		X
Output Contacts held open		X
Event Log Message	X	X
Status available through SCADA	X	X

The Self Check Fail signal, which is available in the Output Matrix, TUI metering and SCADA, can be used to signal an alarm. Note that if this signal is mapped to an output contact, the contact which it is mapped to will only be closed for an alarm condition. If the relay is in the Block condition, the Relay Inoperative contact must be used to signal an alarm.

The status of the Self Check Fail is available through the SCADA services provided by the relay. The digital signal Self Check Fail will indicate that DSP has detected a continuous dc level and the analog metering value Self Check Fail Parameter is used to indicate which condition, Alarm or Block. The failure types and which analog values they are associated with are described in the table below. Both signals are available in DNP and Modbus.

Point Value	Condition
0	Normal
1	Alarm
2	Block
3	Alarm has evolved to block

The Alarm condition is allowed to reset if the continuous dc level drops below the pickup level. The Block condition has no reset level. If power is cycled to the relay it will go into its normal state until the continuous dc level is detected again.

Self Check Fail appears as “Aux. Failure Alarm” in the settings versions before V 10.

Appendix E Modbus RTU Communication Protocol

All metering values available through the terminal user interface are also available via the Modbus protocol. Additionally, the Modbus protocol supports the reading of unit time and time of the readings and provides access to trip and alarm events, including fault location information. All metering readings can be frozen into a snapshot via the "Hold Readings" function (see Force Single Coil function, address 0).

Read Coil Status (Function Code 01)			
Channel	**Address**	**Value**	
Hold Readings	1	0: Readings not held	1: Readings held
Reserved	257	Reserved	Reserved
Output Contact 1	513	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 2	514	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 3	515	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 4	516	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 5	517	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 6	518	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 7	519	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 8	520	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 9	521	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 10	522	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 11	523	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 12	524	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 13	525	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 14	526	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 15	527	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 16	528	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 17	529	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 18	530	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 19	531	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 20	532	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 21	533	0: Contact Open (inactive)	1: Contact Closed (active)
21P1 Trip	769	0: Off (inactive)	1: On (active)
21P2 Trip	770	0: Off (inactive)	1: On (active)
21P3 Trip	771	0: Off (inactive)	1: On (active)
21P4 Trip	772	0: Off (inactive)	1: On (active)
51 Trip	773	0: Off (inactive)	1: On (active)
50 Trip	774	0: Off (inactive)	1: On (active)
21N1 Trip	775	0: Off (inactive)	1: On (active)
21N2 Trip	776	0: Off (inactive)	1: On (active)
21N3 Trip	777	0: Off (inactive)	1: On (active)
21N4 Trip	778	0: Off (inactive)	1: On (active)
68 Power Swing	779	0: Off (inactive)	1: On (active)
Z Circle Trigger	780	0: Off (inactive)	1: On (active)
51N Trip	781	0: Off (inactive)	1: On (active)
50N Trip	782	0: Off (inactive)	1: On (active)

Read Coil Status (Function Code 01)			
46-51 Trip	783	0: Off (inactive)	1: On (active)
46-50 Trip	784	0: Off (inactive)	1: On (active)
Deadline Trip	785	0: Off (inactive)	1: On (active)
Distance Comm Scheme Trip	786	0: Off (inactive)	1: On (active)
Distance Comm Scheme Send	787	0: Off (inactive)	1: On (active)
60 Alarm	788	0: Off (inactive)	1: On (active)
21P2 Alarm	789	0: Off (inactive)	1: On (active)
21P3 Alarm	790	0: Off (inactive)	1: On (active)
21P4 Alarm	791	0: Off (inactive)	1: On (active)
21N2 Alarm	792	0: Off (inactive)	1: On (active)
21N3 Alarm	793	0: Off (inactive)	1: On (active)
21N4 Alarm	794	0: Off (inactive)	1: On (active)
51 Alarm	795	0: Off (inactive)	1: On (active)
51N Alarm	796	0: Off (inactive)	1: On (active)
46-51 Alarm	797	0: Off (inactive)	1: On (active)
Self Check Fail	798	0: Off (inactive)	1: On (active)
ProLogic1	799	0: Off (inactive)	1: On (active)
ProLogic2	800	0: Off (inactive)	1: On (active)
ProLogic3	801	0: Off (inactive)	1: On (active)
ProLogic4	802	0: Off (inactive)	1: On (active)
ProLogic5	803	0: Off (inactive)	1: On (active)
ProLogic6	804	0: Off (inactive)	1: On (active)
ProLogic7	805	0: Off (inactive)	1: On (active)
ProLogic8	806	0: Off (inactive)	1: On (active)
ProLogic9	807	0: Off (inactive)	1: On (active)
ProLogic10	808	0: Off (inactive)	1: On (active)
68 OutBlinder Alarm	809	0: Off (inactive)	1: On (active)
68 InBlinder Alarm	810	0: Off (inactive)	1: On (active)
27 Main Trip	811	0: Off (inactive)	1: On (active)
27 Aux Trip	812	0: Off (inactive)	1: On (active)
59-1 Main Trip	813	0: Off (inactive)	1: On (active)
59-1 Aux Trip	814	0: Off (inactive)	1: On (active)
50LS Main	815	0: Off (inactive)	1: On (active)
25/27/59 Sync Check	816	0: Off (inactive)	1: On (active)
50LS Aux	817	0: Off (inactive)	1: On (active)
Group Logic 1	818	0: Off (inactive)	1: On (active)
Group Logic 2	819	0: Off (inactive)	1: On (active)
Group Logic 3	820	0: Off (inactive)	1: On (active)
Group Logic 4	821	0: Off (inactive)	1: On (active)
Group Logic 5	822	0: Off (inactive)	1: On (active)
Group Logic 6	823	0: Off (inactive)	1: On (active)
Group Logic 7	824	0: Off (inactive)	1: On (active)
Group Logic 8	825	0: Off (inactive)	1: On (active)
Group Logic 9	826	0: Off (inactive)	1: On (active)
Group Logic 10	827	0: Off (inactive)	1: On (active)
Group Logic 11	828	0: Off (inactive)	1: On (active)
Group Logic 12	829	0: Off (inactive)	1: On (active)
Group Logic 13	830	0: Off (inactive)	1: On (active)
Group Logic 14	831	0: Off (inactive)	1: On (active)
Group Logic 15	832	0: Off (inactive)	1: On (active)
Group Logic 16	833	0: Off (inactive)	1: On (active)
79 Initiated	834	0: Off (inactive)	1: On (active)
79 Blocked	835	0: Off (inactive)	1: On (active)

Read Coil Status (Function Code 01)			
50BF-1 Main	836	0: Off (inactive)	1: On (active)
50BF-2 Main	837	0: Off (inactive)	1: On (active)
50BF-1 Aux	838	0: Off (inactive)	1: On (active)
50BF-2 Aux	839	0: Off (inactive)	1: On (active)
79-3 Phase Main Reclose	840	0: Off (inactive)	1: On (active)
79-3 Phase Aux Reclose	841	0: Off (inactive)	1: On (active)
79-3 Phase Lead Lockout	842	0: Off (inactive)	1: On (active)
79-3 Phase Follow Lockout	843	0: Off (inactive)	1: On (active)
81-1 Trip	844	0: Off (inactive)	1: On (active)
81-2 Trip	845	0: Off (inactive)	1: On (active)
81-3 Trip	846	0: Off (inactive)	1: On (active)
81-4 Trip	847	0: Off (inactive)	1: On (active)
50BF Initiate	848	0: Off (inactive)	1: On (active)
ProLogic 11	849	0: Off (inactive)	1: On (active)
ProLogic 12	850	0: Off (inactive)	1: On (active)
ProLogic 13	851	0: Off (inactive)	1: On (active)
ProLogic 14	852	0: Off (inactive)	1: On (active)
ProLogic 15	853	0: Off (inactive)	1: On (active)
ProLogic 16	854	0: Off (inactive)	1: On (active)
ProLogic 17	855	0: Off (inactive)	1: On (active)
ProLogic 18	856	0: Off (inactive)	1: On (active)
ProLogic 19	857	0: Off (inactive)	1: On (active)
ProLogic 20	858	0: Off (inactive)	1: On (active)
ProLogic 21	859	0: Off (inactive)	1: On (active)
ProLogic 22	860	0: Off (inactive)	1: On (active)
ProLogic 23	861	0: Off (inactive)	1: On (active)
ProLogic 24	862	0: Off (inactive)	1: On (active)
79 - 1 Phase A Main Reclose	863	0: Off (inactive)	1: On (active)
79 - 1 Phase B Main Reclose	864	0: Off (inactive)	1: On (active)
79 - 1 Phase C Main Reclose	865	0: Off (inactive)	1: On (active)
79 - 1 Phase A Aux Reclose	866	0: Off (inactive)	1: On (active)
79 - 1 Phase B Aux Reclose	867	0: Off (inactive)	1: On (active)
79 - 1 Phase C Aux Reclose	868	0: Off (inactive)	1: On (active)
79 - 1 Phase Lead Lockout	869	0: Off (inactive)	1: On (active)
79 - 1 Phase Follow Lockout	870	0: Off (inactive)	1: On (active)
79 - 1 Phase Initiated	871	0: Off (inactive)	1: On (active)
79 - 1 Phase Blocked	872	0: Off (inactive)	1: On (active)
1 Phase Open Timeout	873	0: Off (inactive)	1: On (active)
1 Phase Fault Lockout	874	0: Off (inactive)	1: On (active)
3 Phase Fault Lockout	875	0: Off (inactive)	1: On (active)
1/3 Phase Fault Lockout	876	0: Off (inactive)	1: On (active)
DEF Scheme Trip	877	0: Off (inactive)	1: On (active)
DEF Scheme Send	878	0: Off (inactive)	1: On (active)
IRIG-B Signal Loss	879	0: Off (inactive)	1: On (active)
21P5 Trip	880	0: Off (inactive)	1: On (active)
21N5 Trip	881	0: Off (inactive)	1: On (active)
21P5 Alarm	882	0: Off (inactive)	1: On (active)
21N5 Alarm	883	0: Off (inactive)	1: On (active)
59N Def Trip	884	0: Off (inactive)	1: On (active)
59N Inv Trip	885	0: Off (inactive)	1: On (active)
59N Def Alarm	886	0: Off (inactive)	1: On (active)
59N Inv Alarm	887	0: Off (inactive)	1: On (active)
60 CTS Main	888	0: Off (inactive)	1: On (active)

Read Coil Status (Function Code 01)			
60 CTS Aux	889	0: Off (inactive)	1: On (active)
Load Encroachment Block	890	0: Off (inactive)	1: On (active)
59-2 Main Trip	891	0: Off (inactive)	1: On (active)
59-2 Aux Trip	892	0: Off (inactive)	1: On (active)
Successful Reclose Main	893	0: Off (inactive)	1: On (active)
Successful Reclose Aux	894	0: Off (inactive)	1: On (active)
79 Fault lockout	895	0: Off (inactive)	1: On (active)

Read Input Status (Function Code 02)			
Channel	**Address**	**Value**	
External Input 1	10001	0: Off (inactive)	1: On (active)
External Input 2	10002	0: Off (inactive)	1: On (active)
External Input 3	10003	0: Off (inactive)	1: On (active)
External Input 4	10004	0: Off (inactive)	1: On (active)
External Input 5	10005	0: Off (inactive)	1: On (active)
External Input 6	10006	0: Off (inactive)	1: On (active)
External Input 7	10007	0: Off (inactive)	1: On (active)
External Input 8	10008	0: Off (inactive)	1: On (active)
External Input 9	10009	0: Off (inactive)	1: On (active)
External Input 10	10010	0: Off (inactive)	1: On (active)
External Input 11	10011	0: Off (inactive)	1: On (active)
External Input 12	10012	0: Off (inactive)	1: On (active)
External Input 13	10013	0: Off (inactive)	1: On (active)
External Input 14	10014	0: Off (inactive)	1: On (active)
External Input 15	10015	0: Off (inactive)	1: On (active)
External Input 16	10016	0: Off (inactive)	1: On (active)
External Input 17	10017	0: Off (inactive)	1: On (active)
External Input 18	10018	0: Off (inactive)	1: On (active)
External Input 19	10019	0: Off (inactive)	1: On (active)
External Input 20	10020	0: Off (inactive)	1: On (active)
External Input 1 Change of state latch	10257	0: Off (inactive)	1: On (active)
External Input 2 Change of state latch	10258	0: Off (inactive)	1: On (active)
External Input 3 Change of state latch	10259	0: Off (inactive)	1: On (active)
External Input 4 Change of state latch	10260	0: Off (inactive)	1: On (active)
External Input 5 Change of state latch	10261	0: Off (inactive)	1: On (active)
External Input 6 Change of state latch	10262	0: Off (inactive)	1: On (active)
External Input 7 Change of state latch	10263	0: Off (inactive)	1: On (active)
External Input 8 Change of state latch	10264	0: Off (inactive)	1: On (active)
External Input 9 Change of state latch	10265	0: Off (inactive)	1: On (active)
External Input 10 Change of state latch	10266	0: Off (inactive)	1: On (active)
External Input 11 Change of state latch	10267	0: Off (inactive)	1: On (active)
External Input 12 Change of state latch	10268	0: Off (inactive)	1: On (active)
External Input 13 Change of state latch	10269	0: Off (inactive)	1: On (active)
External Input 14 Change of state latch	10270	0: Off (inactive)	1: On (active)
External Input 15 Change of state latch	10271	0: Off (inactive)	1: On (active)
External Input 16 Change of state latch	10272	0: Off (inactive)	1: On (active)
External Input 17 Change of state latch	10273	0: Off (inactive)	1: On (active)
External Input 18 Change of state latch	10274	0: Off (inactive)	1: On (active)
External Input 19 Change of state latch	10275	0: Off (inactive)	1: On (active)
External Input 20 Change of state latch	10276	0: Off (inactive)	1: On (active)

Read Input Status (Function Code 02)			
Virtual Input 1	10513	0: Off (inactive)	1: On (active)
Virtual Input 2	10514	0: Off (inactive)	1: On (active)
Virtual Input 3	10515	0: Off (inactive)	1: On (active)
Virtual Input 4	10516	0: Off (inactive)	1: On (active)
Virtual Input 5	10517	0: Off (inactive)	1: On (active)
Virtual Input 6	10518	0: Off (inactive)	1: On (active)
Virtual Input 7	10519	0: Off (inactive)	1: On (active)
Virtual Input 8	10520	0: Off (inactive)	1: On (active)
Virtual Input 9	10521	0: Off (inactive)	1: On (active)
Virtual Input 10	10522	0: Off (inactive)	1: On (active)
Virtual Input 11	10523	0: Off (inactive)	1: On (active)
Virtual Input 12	10524	0: Off (inactive)	1: On (active)
Virtual Input 13	10525	0: Off (inactive)	1: On (active)
Virtual Input 14	10526	0: Off (inactive)	1: On (active)
Virtual Input 15	10527	0: Off (inactive)	1: On (active)
Virtual Input 16	10528	0: Off (inactive)	1: On (active)
Virtual Input 17	10529	0: Off (inactive)	1: On (active)
Virtual Input 18	10530	0: Off (inactive)	1: On (active)
Virtual Input 19	10531	0: Off (inactive)	1: On (active)
Virtual Input 20	10532	0: Off (inactive)	1: On (active)
Virtual Input 21	10533	0: Off (inactive)	1: On (active)
Virtual Input 22	10534	0: Off (inactive)	1: On (active)
Virtual Input 23	10535	0: Off (inactive)	1: On (active)
Virtual Input 24	10536	0: Off (inactive)	1: On (active)
Virtual Input 25	10537	0: Off (inactive)	1: On (active)
Virtual Input 26	10538	0: Off (inactive)	1: On (active)
Virtual Input 27	10539	0: Off (inactive)	1: On (active)
Virtual Input 28	10540	0: Off (inactive)	1: On (active)
Virtual Input 29	10541	0: Off (inactive)	1: On (active)
Virtual Input 30	10542	0: Off (inactive)	1: On (active)

Read Holding Registers (Function Code 03)			
Channel	**Address**	**Units**	**Scale**
L-PRO Clock Time (UTC). Read all in same query to ensure consistent time reading data			
Milliseconds Now * Millisecond information not supported.	40001	0	1
Seconds Now	40002	0-59	1
Minutes Now	40003	0-59	1
Hours Now	40004	0-23	1
Day of Year Now	40005	1-365 (up to 366 if leap year)	1
Years since 1900	40006	90-137	1
Sync'd to IRIG-B	40007	0: No 1: Yes	1
Time of Acquisition (UTC). Read all in same query to ensure consistent time reading data			
Milliseconds Now * Millisecond information not supported.	40008	0	1
Seconds Now	40009	0-59	1
Minutes Now	40010	0-59	1
Hours Now	40011	0-23	1
Day of Year Now	40012	1-365 (up to 366 if leap year)	1
Years since 1900	40013	90-137	1
Sync'd to IRIG-B	40014	0: No 1: Yes	1
Offset of UTC to IED time.	40015	2's complement half hours, North America is negative	1

Channel	Address	Units	Scale
Line Va Magnitude	40257	kV	10
Line Va Angle	40258	Degrees	10
Line Vb Magnitude	40259	kV	10
Line Vb Angle	40260	Degrees	10
Line Vc Magnitude	40261	kV	10
Line Vc Angle	40262	Degrees	10
Line Ia Magnitude	40263	A	1
Line Ia Angle	40264	Degrees	10
Line Ib Magnitude	40265	A	1
Line Ib Angle	40266	Degrees	10
Line Ic Magnitude	40267	A	1
Line Ic Angle	40268	Degrees	10
I2a Magnitude	40269	A	1
I2a Angle	40270	Degrees	10
I2b Magnitude	40271	A	1
I2b Angle	40272	Degrees	10
I2c Magnitude	40273	A	1

Channel	Address	Units	Scale
I2c Angle	40274	Degrees	10
I3a Magnitude	40275	A	1
I3a Angle	40276	Degrees	10
I3b Magnitude	40277	A	1
I3b Angle	40278	Degrees	10
I3c Magnitude	40279	A	1
I3c Angle	40280	Degrees	10
I4a Magnitude	40281	A	1
I4a Angle	40282	Degrees	10
I4b Magnitude	40283	A	1
I4b Angle	40284	Degrees	10
I4c Magnitude	40285	A	1
I4c Angle	40286	Degrees	10
Bus Va Magnitude	40287	kV	10
Bus Va Angle	40288	Degrees	10
Bus Vb Magnitude	40289	kV	10
Bus Vb Angle	40290	Degrees	10
Bus Vc Magnitude	40291	kV	10
Bus Vc Angle	40292	Degrees	10
Not used	40293		
Not used	40294		
Not used	40295		
Not used	40296		
Not used	40297		
Not used	40298		
Not used	40299		
Not used	40300		
Not used	40301		
Not used	40302		
Not used	40303		
Not used	40304		
Frequency	40305	Hz	100
P	40306	MW	10
Q	40307	Mvar	10
Voltage (V1)	40308	kV	10
Current (I1)	40309	A	1
Active Setting Group Number	40310		
Ia summated Magnitude	40311	A	1
Ia summated Angle	40312	Degrees	10
Ib summated Magnitude	40313	A	1
Ib summated Angle	40314	Degrees	10
Ic summated Magnitude	40315	A	1
Ic summated Angle	40316	Degrees	10
Self Check Fail	40317	N/A	1
S	40318	MVA	10
Power Factor	40319	NA	100
Voltage (V2)	40320	kV	10
Voltage (V0)	40321	kV	10
Current (I2)	40322	A	1
Current (I0)	40323	A	1
Pa	40324	MW	10
Pb	40325	MW	10

Channel	Address	Units	Scale
Pc	40326	MW	10
Qa	40327	Mvar	10
Qb	40328	Mvar	10
Qc	40329	Mvar	10
Sa	40330	MVA	10
Sb	40331	MVA	10
Sc	40332	MVA	10
Power Factor a	40333	NA	100
Power Factor b	40334	NA	100
Power Factor c	40335	NA	100

Read Input Register (Function Code 04)
No input registers supported. Response from IED indicates “ILLEGAL FUNCTION.”

Force Single Coil (Function Code 05)			
Only the “hold readings” coil can be forced. When active, this coil locks all coil, input and holding register readings simultaneously at their present values. When inactive, coil, input and holding register values will read their most recently available state.			
Channel	**Type**	**Address**	**Value**
Hold Readings	Read/Write	01	0000: Readings update normally (inactive) FF00: Hold readings (active)

Preset Single Register (Function Code 06)			
Channel	**Address**	**Value**	**Scaled Up By**
Event Message Control (See below for details of use)			
Refresh event list	40513	No data required	N/A
Acknowledge the current event and get the next event	40514	No data required	N/A
Get the next event (without acknowledge)	40515	No data required	N/A
Event Buffer Size		100	

Diagnostic Subfunctions (Function Code 08)	
Return Query Data (Subfunction 00)	This provides an echo of the submitted message.

Diagnostic Subfunctions (Function Code 08)	
Restart Comm. Option (Subfunction 01)	This restarts the Modbus communications process.
Force Listen Only Mode (Subfunction 04)	No response is returned. IED enters “Listen Only” mode. This mode can only be exited by the “Restart Comm. Option” command.

Report Slave ID (Function Code 17/0x11)			
A fixed response is returned by the IED, including system model, version and issue numbers.			
Channel	**Type**	**Bytes**	**Value**
Model Number	Read Only	0 and 1	0xFA0 = 4000 decimal
Version Number	Read Only	2 and 3	Version number
Issue Number	Read Only	4 and 5	Issue number

- The L-PRO IED model number is 4000.
- Version and issue will each be positive integers, say X and Y.
- The L-PRO is defined as “Model 4000, Version X Issue Y”

Accessing L-PRO Event Information	
All L-PRO detector event messages displayed in the Event Log are available via Modbus. This includes fault location information. The following controls are available.	
Refresh Event List	(Function Code 6, address 40513): Fetches the latest events from the relay's event log and makes them available for Modbus access. The most recent event becomes the current event available for reading.
Acknowledge Current Event and Get Next Event	(Function Code 6, address 40514): Clears the current event from the read registers and places the next event into them. An acknowledged event is no longer available for reading.
Get Next Event	(Function Code 6, address 40515): Places the next event in the read registers without acknowledging the current event. The current event will reappear in the list when Refresh Event List is used.
Size of Current Event Message	(Function Code 3, address 40516): Indicates the number of 16 bit registers used to contain the current event. Event data is stored with 2 characters per register. A reading of zero indicates that there are no unacknowledged events available in the current set. (NB. The Refresh Event List function can be used to check for new events that have occurred since the last Refresh Event List.)
Fault Location Event	(Function Code 3, address 40517): Identifies fault location events. These events are identified by “FL” in this register. Non-fault location events contain “” in this location.
Read Event Message	(Function Code 3, addresses 40518 – 40570): Contains the current message. Two. ASCII characters are packed into each 16 bit register. All unused registers in the set are set to 0.

Accessing L-PRO Event Information	
Fault Information – Type	(Function Code 3, address 40571): If the current event is a fault location event, this register contains the type of fault. The following type bitmap: 0x0001 – Phase A 0x0002 – Phase B 0x0004 – Phase C 0x0008 – Ground Any number of the flags may be set for a given fault. If the relay could not determine the fault type, then the register will not have any flags set and will read 0x0000.
Fault Information – Fault Distance	(Function Code 3, address 40572): If the current event is a fault location event, this register contains the distance to the fault. It is scaled up by a factor of 10. The units are the same as the units set in the relay configuration.
Fault Information – Time of Fault	(Function Code 3, addresses 40573 to 40576): If the current event is a fault location event, these registers contain the time of the fault in seconds since 1970. Each of these 16-bit registers contains an 8-bit portion of a 32-bit time value. Register 40573 contains the upper most 8 bits, and register 40576 contains the lowest 8 bits.

Modbus Event Message Example			
“FL2000Sep21 20:16:16.966 21P1 AB 1.0 km: Trip”			
Register	**Value**		**Meaning**
	High Byte	Low Byte	
40516	0x00	0x1B	Event text size = 27 (0x1B hex)
40517	0x46	0x4C	‘FL’ - Fault locator event
40518	0x32	0x30	‘2’, ‘0’
40519	0x30	0x30	‘0’, ‘0’
40520	0x53	0x65	‘S’, ‘e’
40521	0x70	0x32	‘p’, ‘2’
40522	0x31	0x20	‘1’, ‘<sp>’
40523	0x32	0x30	‘2’, ‘0’
40524	0x3A	0x31	‘:’, ‘1’
40525	0x36	0x3A	‘6’, ‘:’
40526	0x31	0x36	‘1’, ‘6’
40527	0x2E	0x39	‘.’, ‘9’
40528	0x36	0x36	‘6’, ‘6’
40529	0x20	0x32	‘<sp>’, ‘2’
40530	0x31	0x50	‘ 1’, ‘P’
40531	0x31	0x20	‘1’, ‘<sp>‘

Modbus Event Message Example			
40532	0x41	0x42	’A’, ’B’
40533	0x20	0x31	’<sp>’, ’ 1’
40534	0x2E	0x30	’.’, ’0’
40535	0x6B	0x6D	’K’, ’m’
40536	0x3A	0x20	’:’, ’<sp>’
40537	0x54	0x72	‘T’, ‘r’
40538	0x69	0x70	‘i’, ‘p’

Appendix F DNP3 Device Profile

Device Properties

This document shows the device capabilities and the current value of each parameter for the default unit configuration as defined in the default configuration file.

1.1 Device Identification	Capabilities	Current Value	If configurable, list methods
1.1.1 Device Function:	○ Master ● Outstation	○ Master ● Outstation	
1.1.2 Vendor Name:		ERLPhase Power Technologies	
1.1.3 Device Name:		L-PRO 4000	
1.1.4 Device manufacturer's hardware version string:		NA	
1.1.5 Device manufacturer's software version string:		NA	
1.1.6 Device Profile Document Version Number:		V1.3, Oct 21, 2014	
1.1.7 DNP Levels Supported for:	Outstations Only Requests and Responses ☐ None ☐ Level 1 ☒ Level 2 ☐ Level 3		
1.1.8 Supported Function Blocks:	☐ Self-Address Reservation ☐ Object 0 - attribute objects ☐ Data Sets ☐ File Transfer ☐ Virtual Terminal ☐ Mapping to IEC 61850 Object Models defined in a DNP3 XML file		
1.1.9 Notable Additions:	• Start-stop (qualifier codes 0x00 and 0x01), limited quantity (qualifier codes 0x07 and 0x08) and indices (qualifier codes 0x17 and 0x28) for Binary Inputs, Binary Outputs and Analog Inputs (object groups 1, 10 and 30) • 32-bit and 16-bit Analog Inputs with and without flag (variations 1, 2, 3 and 4) • Analog Input events with time (variations 3 and 4) • Fault Location information as analog readings • Event Log messages as Object groups 110 and 111		

1.1 Device Identification	Capabilities	Current Value	If configurable, list methods
1.1.10 Methods to set Configurable Parameters:	☐ XML - Loaded via DNP3 File Transfer ☐ XML - Loaded via other transport mechanism ☐ Terminal - ASCII Terminal Command Line ☒ Software - Vendor software named L-PRO Offliner ☐ Proprietary file loaded via DNP3 file transfer ☐ Proprietary file loaded via other transport mechanism ☐ Direct - Keypad on device front panel ☐ Factory - Specified when device is ordered ☐ Protocol - Set via DNP3 (e.g. assign class) ☐ Other - explain _____		
1.1.11 DNP3 XML files available On-Line:	RdWrFilenameDescription of Contents ☐ dnpDP.xml Complete Device Profile ☐ dnpDPcap.xml Device Profile Capabilities ☐ dnpDPcfg.xml Device Profile config. values ☐ ☐ _____*.xml _____ *The Complete Device Profile Document contains the capabilities, Current Value, and configurable methods columns. *The Device Profile Capabilities contains only the capabilities and configurable methods columns. *The Device Profile Config. Values contains only the Current Value column.	Not supported	
1.1.12 External DNP3 XML files available Off-line:	Rd WrFilenameDescription of Contents ☐ ☐ dnpDP.xml Complete Device Profile ☐ ☐ dnpDPcap.xml Device Profile Capabilities ☐ ☐ dnpDPcfg.xml Device Profile config. values ☐ ☐ _____*.xml _____ *The Complete Device Profile Document contains the capabilities, Current Value, and configurable methods columns. *The Device Profile Capabilities contains only the capabilities and configurable methods columns. *The Device Profile Config. Values contains only the Current Value column.	Not supported	
1.1.13 Connections Supported:	☒ Serial (complete section 1.2) ☒ IP Networking (complete section 1.3) ☐ Other, explain _____		

1.2 Serial Connections		Capabilities	Current Value	If configurable, list methods
1.2.1	Port Name	Port 122		
1.2.2	Serial Connection Parameters:	☐ Asynchronous - 8 Data Bits, 1 Start Bit, 1 Stop Bit, No Parity ☒ Other, explain - Asynchronous with selectable parity	Not configured for DNP	L-PRO Offliner
1.2.3	Baud Rate:	☐ Fixed at _____ ☐ Configurable, range _____ to _____ ☒ Configurable, selectable from 300, 1200, 2400, 9600, 19200, 38400 and 57600 ☐ Configurable, other, describe_____	Not configured for DNP	L-PRO Offliner
1.2.4	Hardware Flow Control (Handshaking): Describe hardware signaling requirements of the interface. Where a transmitter or receiver is inhibited until a given control signal is asserted, it is considered to require that signal prior to sending or receiving characters. Where a signal is asserted prior to transmitting, that signal will be maintained active until after the end of transmission. Where a signal is asserted to enable reception, any data sent to the device when the signal is not active could be discarded.	☐ None **RS-232 / V.24 / V.28 Options:** Before Tx, Asserts: ☐ RTS ☐ DTR Before Rx, Asserts: ☐ RTS ☐ DTR Always Asserts: ☒ RTS ☒ DTR Before Tx, Requires: Asserted / Deasserted ☐ / ☐ CTS ☐ / ☐ DCD ☐ / ☐ DSR ☐ / ☐ RI ☐ / ☐ Rx Inactive Before Rx, Requires: Asserted / Deasserted ☐ / ☐ CTS ☐ / ☐ DCD ☐ / ☐ DSR ☐ / ☐ RI Always Ignores: ☒ CTS ☒ DCD ☒ DSR ☒ RI ☐ Other, explain _____ **RS-422 / V.11 Options:** ☐ Requires Indication before Rx ☐ Asserts Control before Tx ☐ Other, explain _____ **RS-485 Options:** ☐ Requires Rx inactive before Tx ☐ Other, explain _____		
1.2.5	Interval to Request Link Status:	☒ Not Supported ☐ Fixed at_____ seconds ☐ Configurable, range _____ to _____ seconds ☐ Configurable, selectable from __,__,__ seconds ☐ Configurable, other, describe_____		
1.2.6	Supports DNP3 Collision Avoidance:	☒ No ☐ Yes, explain _____		

1.2 Serial Connections	Capabilities	Current Value	If configurable, list methods
1.2.7 Receiver Inter-character Timeout:	☒ Not checked ☐ No gap permitted ☐ Fixed at _____ bit times ☐ Fixed at _____ ms ☐ Configurable, range ____ to ____ bit times ☐ Configurable, range ____ to ____ ms ☐ Configurable, Selectable from __,__,__bit times ☐ Configurable, Selectable from ___, ___, ___ ms ☐ Configurable, other, describe_____ ☐ Variable, explain ____		
1.2.8 Inter-character gaps in transmission:	☒ None (always transmits with no inter-character gap) ☐ Maximum _____ bit times ☐ Maximum _____ ms		

1.3 IP Networking	Capabilities	Current Value	If configurable, list methods
1.3.1 Port Name	Port 119 and 120 Network		
1.3.2 Type of End Point:	☐ TCP Initiating (Master Only) ☒ TCP Listening (Outstation Only) ☐ TCP Dual (required for Masters) ☒ UDP Datagram (required)	Not configured for DNP	L-PRO Offliner
1.3.3 IP Address of this Device:		192.168.100.101	L-PRO Maintenance utilities
1.3.4 Subnet Mask:		Not set	L-PRO Maintenance utilities
1.3.5 Gateway IP Address:		Not set	L-PRO Maintenance utilities
1.3.6 Accepts TCP Connections or UDP Datagrams from:	☒ Allows all (show as *.*.*.* in 1.3.7) ☒ Limits based on an IP address ☒ Limits based on list of IP addresses ☐ Limits based on a wildcard IP address ☐ Limits based on list of wildcard IP addresses ☐ Other validation, explain_____	Limits based on an IP address	L-PRO Offliner
1.3.7 IP Address(es) from which TCP Connections or UDP Datagrams are accepted:		192.168.1.1	L-PRO Offliner
1.3.8 TCP Listen Port Number:	☐ Not Applicable (Master w/o dual end point) ☐ Fixed at 20,000 ☒ Configurable, range 1025 to 32737 ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	20,000	L-PRO Offliner
1.3.9 TCP Listen Port Number of remote device:	☒ Not Applicable (Outstation w/o dual end point) ☐ Fixed at 20,000 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	NA	
1.3.10 TCP Keep-alive timer:	☐ Fixed at _____ms ☒ Configurable, range 5 to 3,600 s ☐ Configurable, selectable from ___,___,___ms ☐ Configurable, other, describe_____	Disabled	L-PRO Offliner
1.3.11 Local UDP port:	☐ Fixed at 20,000 ☒ Configurable, range 1025 to 32737 ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Let system choose (Master only)	20,000	L-PRO Offliner
1.3.12 Destination UDP port for initial unsolicited null responses (UDP only Outstations):	☒ None ☐ Fixed at 20,000 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	NA	

1.3 IP Networking	Capabilities	Current Value	If configurable, list methods
1.3.13 Destination UDP port for responses:	☐ None ☐ Fixed at 20,000 ☒ Configurable, range 1025 to 32737 ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Use source port number	20,000	L-PRO Offliner
1.3.14 Multiple master connections (Outstations Only):	☒ Supports multiple masters (Outstations only) If supported, the following methods may be used: ☒ Method 1 (based on IP address) - required ☒ Method 2 (based on IP port number) - recommended ☒ Method 3 (browsing for static data) - optional	Method 1 (based on IP address)	L-PRO Offliner
1.3.15 Time synchronization support:	☐ DNP3 LAN procedure (function code 24) ☐ DNP3 Write Time (not recommended over LAN) ☐ Other, explain _____ ☒ Not Supported		

1.4 Link Layer	Capabilities	Current Value	If configurable, list methods
1.4.1 Data Link Address:	☐ Fixed at_____ ☒ Configurable, range 1 to 65519 ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	1	L-PRO Offliner
1.4.2 DNP3 Source Address Validation:	☒ Never ☐ Always, one address allowed (shown in 1.4.3) ☐ Always, any one of multiple addresses allowed ☐ (each selectable as shown in 1.4.3) ☐ Sometimes, explain_____		
1.4.3 DNP3 Source Address(es) expected when Validation is Enabled:	☐ Configurable to any 16 bit DNP Data Link Address value ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	NA	
1.4.4 Self Address Support using address 0xFFFC:	☐ Yes (only allowed if configurable) ☒ No	NA	
1.4.5 Sends Confirmed User Data Frames:	☐ Always ☐ Sometimes, explain _____ ☐ Never ☒ Configurable, either always or never		L-PRO Offliner (to disable, set Data Link Time-out to 0)
1.4.6 Data Link Layer Confirmation Timeout:	☐ None ☐ Fixed at __ ms ☒ Configurable, range 0 to 2,000 ms ☐ Configurable, selectable from_____ms ☐ Configurable, other, describe_____ ☐ Variable, explain _____	500	
1.4.7 Maximum Data Link Retries:	☐ Never Retries ☒ Fixed at 3 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	3	
1.4.8 Maximum number of octets Transmitted in a Data Link Frame:	☒ Fixed at 292 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	292	
1.4.9 Maximum number of octets that can be Received in a Data Link Frame:	☒ Fixed at 292 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	292	

1.5 Application Layer		Capabilities	Current Value	If configurable, list methods
1.5.1	Maximum number of octets Transmitted in an Application Layer Fragment other than File Transfer:	☒ Fixed at 2048 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	2048	
1.5.2	Maximum number of octets Transmitted in an Application Layer Fragment containing File Transfer:	☐ Fixed at _____ ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	NA	
1.5.3	Maximum number of octets that can be Received in an Application Layer Fragment:	☒ Fixed at 2048 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	2048	
1.5.4	Timeout waiting for Complete Application Layer Fragment:	☐ None ☒ Fixed at 2,000 ms ☐ Configurable, range _____ to _____ms ☐ Configurable, selectable from ___,___,___ms ☐ Configurable, other, describe_____ ☐ Variable, explain _____	2,000 ms	
1.5.5	Maximum number of objects allowed in a single control request for CROB (group 12):	☒ Fixed at 16 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Variable, explain _____	16	
1.5.6	Maximum number of objects allowed in a single control request for Analog Outputs (group 41):	☐ Fixed at _ ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Variable, explain _____	Analog Outputs not supported	
1.5.7	Maximum number of objects allowed in a single control request for Data Sets (groups 85,86,87):	☐ Fixed at __ ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Variable, explain _____	Data Sets not supported	
1.5.8	Supports mixing object groups (AOBs, CROBs and Data Sets) in the same control request:	☐ Not applicable - controls are not supported ☐ Yes ☒ No	Analog Outputs not supported	

1.6 Fill Out The Following Items For Outstations Only	Capabilities	Current Value	If configurable, list methods
1.6.1 Timeout waiting for Application Confirm of solicited response message:	☐ None ☒ Fixed at 5,000 ms ☐ Configurable, range _____ to _____ms ☐ Configurable, selectable from ___,___,___ms ☐ Configurable, other, describe_____ ☐ Variable, explain _____	5,000 ms	
1.6.2 How often is time synchronization required from the master?	☒ Never needs time ☐ Within _____ seconds after IIN1.4 is set ☐ Periodically every _____ seconds		
1.6.3 Device Trouble Bit IIN1.6:	☐ Never used ☒ Reason for setting: Unable to access requested data or execute CROB, assuming a valid request has been received		
1.6.4 File Handle Timeout:	☒ Not applicable, files not supported ☐ Fixed at_____ ms ☐ Configurable, range _____ to _____ms ☐ Configurable, selectable from ___,___,___ms ☐ Configurable, other, describe_____ ☐ Variable, explain _____		
1.6.5 Event Buffer Overflow Behaviour:	☐ Discard the oldest event ☒ Discard the newest event ☐ Other, explain _____		
1.6.6 Event Buffer Organization:	• Single buffer for the Object Groups 2 and 32, size 200. • Separate buffer for the Object Group 111, size 100. • Separate buffer for the Fault Locator events, size 100.		
1.6.7 Sends Multi-Fragment Responses:	☒ Yes ☐ No		
1.6.8 DNP Command Settings preserved through a device reset:	☐ Assign Class ☐ Analog Deadbands ☐ Data Set Prototypes ☐ Data Set Descriptors	Not supported	

1.7 Outstation Unsolicited Response Support	Capabilities	Current Value	If configurable, list methods
1.7.1 Supports Unsolicited Reporting:	☒ Not Supported ☐ Configurable, selectable from On and Off	NA	

1.8 Outstation Performance	Capabilities	Current Value	If configurable, list methods
1.8.1 Maximum Time Base Drift (milliseconds per minute):		NA, not synchronized by DNP	
1.8.2 When does outstation set IIN1.4?	☒ Never ☐ Asserted at startup until first Time Synchronization request received ☐ Periodically, range ____to____ seconds ☐ Periodically, selectable from ____,____,___ seconds ☐ Range ____to____ seconds after last time sync ☐ Selectable from___,___,___seconds after last time sync ☐ When time error may have drifted by range ____to____ ms ☐ When time error may have drifted by selectable from ____,____,___	NA	
1.8.3 Maximum Internal Time Reference Error when set via DNP (ms):		NA	
1.8.4 Maximum Delay Measurement error (ms):		NA	
1.8.5 Maximum Response time (ms):		100 ms (for the case all supported points mapped to the DNP point lists)	L-PRO Offliner
1.8.6 Maximum time from start-up to IIN 1.4 assertion (ms):		NA	
1.8.7 Maximum Event Time-tag error for local Binary and Double-bit I/O (ms):		• 0.1736 ms for 60Hz systems • 0.2083 ms for 50 Hz systems	
1.8.8 Maximum Event Time-tag error for local I/O other than Binary and Double-bit data types (ms):		• 0.1736 ms for 60Hz systems • 0.2083 ms for 50 Hz systems	

Capabilities and Current Settings for Device Database

The following tables identify the capabilities and current settings for each DNP3 data type. Each data type also provides a table defining the data points available in the device, default point lists configuration and a description of how this information can be obtained in case of customized point configuration.

2.1 Single-Bit Binary Inputs Static (Steady-State) Group Number: 1 Event Group Number: 2	**Capabilities**	**Current Value**	**If configurable, list methods**
2.1.1 Static Variation reported when variation 0 requested:	☒ Variation 1 - Single-bit Packed format ☐ Variation 2 - Single-bit with flag ☐ Based on point Index (add column to table below)		
2.1.2 Event Variation reported when variation 0 requested:	☐ Variation 1 - without time ☒ Variation 2 - with absolute time ☐ Variation 3 - with relative time ☐ Based on point Index (add column to table below)		
2.1.3 Event reporting mode:	☐ Only most recent ☒ All events		
2.1.4 Binary Inputs included in Class 0 response:	☒ Always ☐ Never ☐ Only if point is assigned to Class 1, 2, or 3 ☐ Based on point Index (add column to table below)		L-PRO Offliner
2.1.5 Definition of Binary Input Point List:	☐ Fixed, list shown in table below ☒ Configurable ☐ Other, explain_____	Complete list is shown in the table below; points excluded from the default configuration are marked with '*'	L-PRO Offliner

Notes	1. Binary Inputs are scanned with 1 ms resolution. 2. Binary Input data points are user selectable; the data points available in the device for any given Binary Input point selection can be obtained through the L-PRO Offliner software (see SCADA Setting Summary).

Point Index	Name	Default Class Assigned to Events (1, 2, 3 or none)	Name for State when value is 0	Name for State when value is 1	Description
0	External Input 1	1	Inactive	Active	
1	External Input 2	1	Inactive	Active	
2	External Input 3	1	Inactive	Active	
3	External Input 4	1	Inactive	Active	
4	External Input 5	1	Inactive	Active	
5	External Input 6	1	Inactive	Active	
6	External Input 7	1	Inactive	Active	
7	External Input 8	1	Inactive	Active	
8	External Input 9	1	Inactive	Active	
9	Virtual Input 1	1	Inactive	Active	
10	Virtual Input 2	1	Inactive	Active	
11	Virtual Input 3	1	Inactive	Active	
12	Virtual Input 4	1	Inactive	Active	
13	Virtual Input 5	1	Inactive	Active	
14	Virtual Input 6	1	Inactive	Active	
15	Virtual Input 7	1	Inactive	Active	
16	Virtual Input 8	1	Inactive	Active	
17	Virtual Input 9	1	Inactive	Active	
18	Virtual Input 10	1	Inactive	Active	
19	Virtual Input 11	1	Inactive	Active	
20	Virtual Input 12	1	Inactive	Active	
21	Virtual Input 13	1	Inactive	Active	
22	Virtual Input 14	1	Inactive	Active	
23	Virtual Input 15	1	Inactive	Active	
24	Virtual Input 16	1	Inactive	Active	
25	Virtual Input 17	1	Inactive	Active	
26	Virtual Input 18	1	Inactive	Active	
27	Virtual Input 19	1	Inactive	Active	
28	Virtual Input 20	1	Inactive	Active	
29	Virtual Input 21	1	Inactive	Active	
30	Virtual Input 22	1	Inactive	Active	
31	Virtual Input 23	1	Inactive	Active	

32	Virtual Input 24	1	Inactive	Active	
33	Virtual Input 25	1	Inactive	Active	
34	Virtual Input 26	1	Inactive	Active	
35	Virtual Input 27	1	Inactive	Active	
36	Virtual Input 28	1	Inactive	Active	
37	Virtual Input 29	1	Inactive	Active	
38	Virtual Input 30	1	Inactive	Active	
39	Fault Information Available	1	Inactive	Active	
40*	External Input 10	1	Inactive	Active	
41*	External Input 11	1	Inactive	Active	
42*	External Input 12	1	Inactive	Active	
43*	External Input 13	1	Inactive	Active	
44*	External Input 14	1	Inactive	Active	
45*	External Input 15	1	Inactive	Active	
46*	External Input 16	1	Inactive	Active	
47*	External Input 17	1	Inactive	Active	
48*	External Input 18	1	Inactive	Active	
49*	External Input 19	1	Inactive	Active	
50*	External Input 20	1	Inactive	Active	
51	21P1 Trip	1	Inactive	Active	
52	21P2 Trip	1	Inactive	Active	
53	21P3 Trip	1	Inactive	Active	
54	21P4 Trip	1	Inactive	Active	
55	51 Trip	1	Inactive	Active	
56	50 Trip	1	Inactive	Active	
57	21N1 Trip	1	Inactive	Active	
58	21N2 Trip	1	Inactive	Active	
59	21N3 Trip	1	Inactive	Active	
60	21N4 Trip	1	Inactive	Active	
61	68 Power Swing	1	Inactive	Active	
62	51N Trip	1	Inactive	Active	
63	50N Trip	1	Inactive	Active	
64	46-51 Trip	1	Inactive	Active	
65	46-50 Trip	1	Inactive	Active	
66	SOTF	1	Inactive	Active	
67	Distance Scheme Trip	1	Inactive	Active	

68	Distance Scheme Send	1	Inactive	Active	
69	60 LOP	1	Inactive	Active	
70	Self Check Fail	1	Inactive	Active	
71	27 Main Trip	1	Inactive	Active	OR of 27 Main A, B and C Trip
72	27 Aux Trip	1	Inactive	Active	OR of 27 Aux A, B and C Trip
73	59-1 Main Trip	1	Inactive	Active	OR of 59-1 Main A, B and C Trip
74	59-1 Aux Trip	1	Inactive	Active	OR of 59-1 Aux A, B and C Trip
75	50LS Main	1	Inactive	Active	OR of 50LS Main A, B and C Trip
76	50LS Aux	1	Inactive	Active	OR of 50LS Aux A, B and C Trip
77	50BF-1 Main	1	Inactive	Active	
78	50BF-2 Main	1	Inactive	Active	
79	81-1 Trip	1	Inactive	Active	OR of 81-1 OF, UF and FRC Trip
80	81-2 Trip	1	Inactive	Active	OR of 81-2 OF, UF and FRC Trip
81	81-3 Trip	1	Inactive	Active	OR of 81-3 OF, UF and FRC Trip
82	81-4 Trip	1	Inactive	Active	OR of 81-4 OF, UF and FRC Trip
83	ProLogic1	1	Inactive	Active	
84	ProLogic2	1	Inactive	Active	
85	ProLogic3	1	Inactive	Active	
86	ProLogic4	1	Inactive	Active	
87	ProLogic5	1	Inactive	Active	
88	ProLogic6	1	Inactive	Active	
89	ProLogic7	1	Inactive	Active	
90	ProLogic8	1	Inactive	Active	
91	ProLogic9	1	Inactive	Active	
92	ProLogic10	1	Inactive	Active	
93	ProLogic11	1	Inactive	Active	
94	ProLogic12	1	Inactive	Active	
95*	Output Contact 1	1	Open	Closed	
96*	Output Contact 2	1	Open	Closed	
97*	Output Contact 3	1	Open	Closed	

98*	Output Contact 4	1	Open	Closed	
99*	Output Contact 5	1	Open	Closed	
100*	Output Contact 6	1	Open	Closed	
101*	Output Contact 7	1	Open	Closed	
102*	Output Contact 8	1	Open	Closed	
103*	Output Contact 9	1	Open	Closed	
104*	Output Contact 10	1	Open	Closed	
105*	Output Contact 11	1	Open	Closed	
106*	Output Contact 12	1	Open	Closed	
107*	Output Contact 13	1	Open	Closed	
108*	Output Contact 14	1	Open	Closed	
109*	Output Contact 15	1	Open	Closed	
110*	Output Contact 16	1	Open	Closed	
111*	Output Contact 17	1	Open	Closed	
112*	Output Contact 18	1	Open	Closed	
113*	Output Contact 19	1	Open	Closed	
114*	Output Contact 20	1	Open	Closed	
115*	Output Contact 21	1	Open	Closed	
116	Z Circle Trigger	1	Inactive	Active	
117	21P2 Alarm	1	Inactive	Active	
118	21P3 Alarm	1	Inactive	Active	
119	21P4 Alarm	1	Inactive	Active	
120	21N2 Alarm	1	Inactive	Active	
121	21N3 Alarm	1	Inactive	Active	
122	21N4 Alarm	1	Inactive	Active	
123	51 Alarm	1	Inactive	Active	
124	51N Alarm	1	Inactive	Active	
125	46-51 Alarm	1	Inactive	Active	
126	68 OutBlinder Alarm	1	Inactive	Active	
127	68 InBlinder Alarm	1	Inactive	Active	
128	25/27/59 Sync Check	1	Inactive	Active	
129	50BF-1 Aux	1	Inactive	Active	
130	50BF-2 Aux	1	Inactive	Active	
131	50BF Initiate	1	Inactive	Active	
132	79 – 3 Phase Initiated	1	Inactive	Active	
133	79 – 3 Phase Blocked	1	Inactive	Active	

134	79 – 3 Phase Main Reclose	1	Inactive	Active	
135	79 – 3 Phase Aux Reclose	1	Inactive	Active	
136	79 – 3 Phase Lead Lockout	1	Inactive	Active	
137	79 – 3 Phase Follow Lockout	1	Inactive	Active	
138	79 – 1 Phase A Main Reclose	1	Inactive	Active	
139	79 – 1 Phase B Main Reclose	1	Inactive	Active	
140	79 – 1 Phase C Main Reclose	1	Inactive	Active	
141	79 – 1 Phase A Aux Reclose	1	Inactive	Active	
142	79 – 1 Phase B Aux Reclose	1	Inactive	Active	
143	79 – 1 Phase C Aux Reclose	1	Inactive	Active	
144	79 – 1 Phase Lead Lockout	1	Inactive	Active	
145	79 – 1 Phase Follow Lockout	1	Inactive	Active	
146	79 – 1 Phase Initiated	1	Inactive	Active	
147	79 – 1 Phase Blocked	1	Inactive	Active	
148	1 Phase Open Timeout	1	Inactive	Active	
149	1 Phase Fault Lockout	1	Inactive	Active	
150	3 Phase Fault Lockout	1	Inactive	Active	
151	1/3 Phase Fault Lockout	1	Inactive	Active	
152	DEF Scheme Trip	1	Inactive	Active	
153	DEF Scheme Send	1	Inactive	Active	
154	ProLogic13	1	Inactive	Active	
155	ProLogic14	1	Inactive	Active	
156	ProLogic15	1	Inactive	Active	
157	ProLogic16	1	Inactive	Active	
158	ProLogic17	1	Inactive	Active	
159	ProLogic18	1	Inactive	Active	
160	ProLogic19	1	Inactive	Active	
161	ProLogic20	1	Inactive	Active	
162	ProLogic21	1	Inactive	Active	
163	ProLogic22	1	Inactive	Active	
164	ProLogic23	1	Inactive	Active	
165	ProLogic24	1	Inactive	Active	
166	IRIG-B Signal Loss	1	Inactive	Active	
167*	27 Main A Trip	1	Inactive	Active	
168*	27 Main B Trip	1	Inactive	Active	
169*	27 Main C Trip	1	Inactive	Active	

170*	27 Aux A Trip	1	Inactive	Active	
171*	27 Aux B Trip	1	Inactive	Active	
172*	27 Aux C Trip	1	Inactive	Active	
173*	59-1 Main A Trip	1	Inactive	Active	
174*	59-1 Main B Trip	1	Inactive	Active	
175*	59-1 Main C Trip	1	Inactive	Active	
176*	59-1 Aux A Trip	1	Inactive	Active	
177*	59-1 Aux B Trip	1	Inactive	Active	
178*	59-1 Aux C Trip	1	Inactive	Active	
179*	50LS Main A	1	Inactive	Active	
180*	50LS Main B	1	Inactive	Active	
181*	50LS Main C	1	Inactive	Active	
182*	50LS Aux A	1	Inactive	Active	
183*	50LS Aux B	1	Inactive	Active	
184*	50LS Aux C	1	Inactive	Active	
185*	81-1 OF Trip	1	Inactive	Active	
186*	81-1 UF Trip	1	Inactive	Active	
187*	81-1 FRC Trip	1	Inactive	Active	
188*	81-2 OF Trip	1	Inactive	Active	
189*	81-2 UF Trip	1	Inactive	Active	
190*	81-2 FRC Trip	1	Inactive	Active	
191*	81-3 OF Trip	1	Inactive	Active	
192*	81-3 UF Trip	1	Inactive	Active	
193*	81-3 FRC Trip	1	Inactive	Active	
194*	81-4 OF Trip	1	Inactive	Active	
195*	81-4 UF Trip	1	Inactive	Active	
196*	81-4 FRC Trip	1	Inactive	Active	
197	21P5 Trip	1	Inactive	Active	
198	21N5 Trip	1	Inactive	Active	
199	21P5 Alarm	1	Inactive	Active	
200	21N5 Alarm	1	Inactive	Active	
201	59N Def Trip	1	Inactive	Active	
202	59N Inv Trip	1	Inactive	Active	
203	59N Def Alarm	1	Inactive	Active	
204	59N Inv Alarm	1	Inactive	Active	
205	60 CTS Main	1	Inactive	Active	

206	60 CTS Aux	1	Inactive	Active	
207	Load Encroachment	1	Inactive	Active	
208	59-2 Main Trip	1	Inactive	Active	OR of 59-2 Main A, B and C Trip
209	59-2 Aux Trip	1	Inactive	Active	OR of 59-2 Aux A, B and C Trip
210*	59-2 Main A Trip	1	Inactive	Active	
211*	59-2 Main B Trip	1	Inactive	Active	
212*	59-2 Main C Trip	1	Inactive	Active	
213*	59-2 Aux A Trip	1	Inactive	Active	
214*	59-2 Aux B Trip	1	Inactive	Active	
215*	59-2 Aux C Trip	1	Inactive	Active	
216	Successful Reclose Main	1	Inactive	Active	
217	Successful Reclose Aux	1	Inactive	Active	
218	79 Fault lockout	1	Inactive	Active	

2.2 Binary Output Status And Control Relay Output Block Binary Output Status Group Number: 10 Binary Output Event Group Number: 11 CROB Group Number: 12 Binary Output Command Event Object Num: 13	**Capabilities**	**Current Value**	**If configurable, list methods**
2.2.1 Minimum pulse time allowed with Trip, Close, and Pulse On commands:	☒ Fixed at 0,000 ms (hardware may limit this further) ☐ Based on point Index (add column to table below)		
2.2.2 Maximum pulse time allowed with Trip, Close, and Pulse On commands:	☒ Fixed at 0,000 ms (hardware may limit this further) ☐ Based on point Index (add column to table below)		
2.2.3 Binary Output Status included in Class 0 response:	☒ Always ☐ Never ☐ Only if point is assigned to Class 1, 2, or 3 ☐ Based on point Index (add column to table below)		
2.2.4 Reports Output Command Event Objects:	☒ Never ☐ Only upon a successful Control ☐ Upon all control attempts	Not supported	
2.2.5 Event Variation reported when variation 0 requested:	☐ Variation 1 - without time ☐ Variation 2 - with absolute time ☐ Based on point Index (add column to table below)	Not supported	L-PRO Offliner (See Note 2 below)
2.2.6 Command Event Variation reported when variation 0 requested:	☐ Variation 1 - without time ☐ Variation 2 - with absolute time ☐ Based on point Index (add column to table below)	Not supported	L-PRO Offliner (See Note 2 below)
2.2.7 Event reporting mode:	☐ Only most recent ☐ All events	Not supported	L-PRO Offliner (See Note 2 below)
2.2.8 Command Event reporting mode:	☐ Only most recent ☐ All events	Not supported	
2.2.9 Maximum Time between Select and Operate:	☐ Not Applicable ☒ Fixed at 10 seconds ☐ Configurable, range _____ to _____ seconds ☐ Configurable, selectable from___,___,___seconds ☐ Configurable, other, describe_____ ☐ Variable, explain _____ ☐ Based on point Index (add column to table below)	10 s	
2.2.10 Definition of Binary Output Status/Control relay output block (CROB) Point List:	☐ Fixed, list shown in table below ☒ Configurable ☐ Other, explain_____	Complete list is shown in the table below; points excluded from the default configuration are marked with '*'	L-PRO Offliner

NOTES

1. Binary Outputs are scanned with 500 ms resolution.

2. Events are not supported for Binary Outputs (group 10), but most of Binary Output points can be mapped to Binary Inputs (group 2) with full Event and Class Data support. See L-PRO Offliner/DNP Configuration/Point Map screen for complete point lists and configuration options.

3. Virtual Inputs (default Binary Output points 94-123) can be used to control relay output contacts. See L-PRO Offliner/Setting Group X/Output Matrix screen for configuration options.

4. Binary Output data points are user selectable; the data points available in the device for any given Binary Output point selection can be obtained through the L-PRO Offliner software (see SCADA Setting Summary).

Point Index	Name	Supported Control Operations											Name for State when value is 0	Name for State when value is 1	Default Class Assigned to Events (1, 2, 3 or none)		Description
		Select/Operate	Direct Operate	Direct Operate - No Ack	Pulse On / NUL	Pulse Off	Latch On / NUL	Latch Off / NUL	Trip	Close	Count > 1	Cancel Currently Running Operation			Change	Command	
0	Output contact 1	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
1	Output contact 2	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
2	Output contact 3	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
3	Output contact 4	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
4	Output contact 5	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
5	Output contact 6	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
6	Output contact 7	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
7	Output contact 8	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
8	Output contact 9	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
9	Output contact 10	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
10	Output contact 11	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
11	Output contact 12	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
12	Output contact 13	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
13	Output contact 14	-	-	-	-	-	-	-	-	-	-	-	Open	Closed	None	None	
14	Virtual Input 1	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
15	Virtual Input 2	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
16	Virtual Input 3	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
17	Virtual Input 4	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
18	Virtual Input 5	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s

Point Index	Name	Supported Control Operations											Name for State when value is 0	Name for State when value is 1	Default Class Assigned to Events (1, 2, 3 or none)		Description
		Select/Operate	Direct Operate	Direct Operate - No Ack	Pulse On / NUL	Pulse Off	Latch On / NUL	Latch Off / NUL	Trip	Close	Count > 1	Cancel Currently Running Operation			Change	Command	
19	Virtual Input 6	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
20	Virtual Input 7	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
21	Virtual Input 8	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
22	Virtual Input 9	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
23	Virtual Input 10	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
24	Virtual Input 11	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
25	Virtual Input 12	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
26	Virtual Input 13	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
27	Virtual Input 14	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
28	Virtual Input 15	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
29	Virtual Input 16	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
30	Virtual Input 17	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
31	Virtual Input 18	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
32	Virtual Input 19	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
33	Virtual Input 20	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
34	Virtual Input 21	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
35	Virtual Input 22	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
36	Virtual Input 23	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
37	Virtual Input 24	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
38	Virtual Input 25	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
39	Virtual Input 26	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
40	Virtual Input 27	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
41	Virtual Input 28	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
42	Virtual Input 29	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
43	Virtual Input 30	Y	Y	Y	Y	-	Y	-	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
44	Get Next Fault Event	Y	Y	Y	Y	-	Y	-	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1 s
45*	Output Contact 15	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	

Point Index	Name	Supported Control Operations											Name for State when value is 0	Name for State when value is 1	Default Class Assigned to Events (1, 2, 3 or none)		Description
		Select/Operate	Direct Operate	Direct Operate - No Ack	Pulse On / NUL	Pulse Off	Latch On / NUL	Latch Off / NUL	Trip	Close	Count > 1	Cancel Currently Running Operation			Change	Command	
46*	Output Contact 16	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
47*	Output Contact 17	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
48*	Output Contact 18	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
49*	Output Contact 19	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
50*	Output Contact 20	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
51*	Output Contact 21	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	

2.3 Analog Input Points Static (Steady-State) Group Number: 30 Event Group Number: 32	**Capabilities**	**Current Value**	**If configurable, list methods**
2.3.1 Static Variation reported when variation 0 requested:	☐ Variation 1 - 32-bit with flag ☐ Variation 2 - 16-bit with flag ☐ Variation 3 - 32-bit without flag ☒ Variation 4 - 16-bit without flag ☐ Variation 5 - single-precision floating point with flag ☐ Variation 6 - double-precision floating point with flag ☐ Based on point Index (add column to table below)		
2.3.2 Event Variation reported when variation 0 requested:	☐ Variation 1 - 32-bit without time ☒ Variation 2 - 16-bit without time ☐ Variation 3 - 32-bit with time ☐ Variation 4 - 16-bit with time ☐ Variation 5 - single-precision floating point w/o time ☐ Variation 6 - double-precision floating point w/o time ☐ Variation 7 - single-precision floating point with time ☐ Variation 8 - double-precision floating point with time ☐ Based on point Index (add column to table below)		
2.3.3 Event reporting mode:	☐ Only most recent ☒ All events		
2.3.4 Analog Inputs Included in Class 0 response:	☒ Always ☐ Never ☐ Only if point is assigned to Class 1, 2, or 3 ☐ Based on point Index (add column to table below)		
2.3.5 How Deadbands are set:	☐ A. Global Fixed ☐ B. Configurable through DNP ☒ C. Configurable via other means ☐ D. Other, explain _____ ☐ Based on point Index - column specifies which of the options applies, B, C, or D		L-PRO Offliner
2.3.6 Analog Deadband Algorithm: simple - just compares the difference from the previous reported value	☒ Simple ☐ Integrating ☐ Other, explain _____		
2.3.7 Definition of Analog Input Point List:	☐ Fixed, list shown in table below ☒ Configurable ☐ Other, explain_____	Complete list is shown in the table below; points excluded from the default configuration are marked with '*'	L-PRO Offliner

NOTES

1. Analog Inputs are scanned with 500 ms resolution.

2. Nominal values in calculations for the following table are based on 69V secondary voltage * PT ratio for voltage channels, and either 1 A or 5A secondary current * CT ratio for current channels dependent upon the format of CT installed in the L-PRO.

3. Analog Input data points are user selectable; the data points available in the device for any given Analog Input point selection can be obtained through the L-PRO Offliner software (see SCADA Setting Summary).

4. When a fault location event is available, Binary Input Fault Information Available (default point index 39) is asserted while there are still fault location events in the buffer (size 100). When a Pulse or Latch is received for the Binary Output Get Next Fault Event (default point index 44, previous state is not important), fault event information is put into the Analog Inputs. If there is no fault location event available when the Binary Output is pulsed, the fault type is set to zero.

Not all fault location events are reported trough DNP. In a burst of fault locations from a fault, only the first processed event is available through DNP, all other events within the following 100 ms interval are ignored. Outside 100 ms from the processed fault location event, the system accepts another fault location event and performs the same filtering. In addition, only fault location events generated by trip elements are available.

The following bitmap id used for the fault information Type points:

0x0001 Phase A
0x0002 Phase B
0x0004 Phase C
0x0008 Ground

Point Index	Name	Default Class Assigned to Events (1, 2, 3 or none)	Transmitted Value[a]		Scaling[b]		Units	Resolution[c] (default/ maximal)	Description
			Minimum	Maximum[d]	Multiplier (default/ (range))	Offset			
0	Line Va Magnitude	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	kV	0.1 / 0.00001	
1	Line Va Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
2	Line Vb Magnitude	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	kV	0.1 / 0.00001	
3	Line Vb Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
4	Line Vc Magnitude	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	kV	0.1 / 0.00001	
5	Line Vc Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
6	Line Ia Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
7	Line Ia Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
8	Line Ib Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
9	Line Ib Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	

Point Index	Name	Default Class Assigned to Events (1, 2, 3 or none)	Transmitted Value[a]		Scaling[b]		Units	Resolution[c] (default/ maximal)	Description
			Minimum	Maximum[d]	Multiplier (default/ (range))	Offset			
10	Line Ic Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
11	Line Ic Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
12	I2a Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
13	I2a Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
14	I2b Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
15	I2b Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
16	I2c Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
17	I2c Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
18	I3a Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
19	I3a Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
20	I3b Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
21	I3b Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
22	I3c Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
23	I3c Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
24	I4a Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
25	I4a Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
26	I4b Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
27	I4b Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
28	I4c Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
29	I4c Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
30	Bus Va Magnitude	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	kV	0.1 / 0.00001	
31	Bus Va Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
32	Bus Vb Magnitude	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	kV	0.1 / 0.00001	
33	Bus Vb Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
34	Bus Vc Magnitude	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	kV	0.1 / 0.00001	
35	Bus Vc Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
36	Frequency	2	0	Configurable	0.01 / (0.001 - 1.0)	0.0	Hz	0.01 / 0.001	
37	P	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	MW	0.1 / 0.00001	
38	Q	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	Mvar	0.1 / 0.00001	
39	Voltage (V1)	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	kV	0.1 / 0.00001	
40	Current (I1)	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
41*	Line Za Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	Om	1.0 / 0.01	
42*	Line Za Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	degrees	0.1 / 0.01	
43*	Line Zb Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	Om	1.0 / 0.01	
44*	Line Zb Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	degrees	0.1 / 0.01	
45*	Line Zc Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	Om	1.0 / 0.01	
46*	Line Zc Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	degrees	0.1 / 0.01	
47*	Not used	2	0	0	1.0	0.0	NA	NA	Retained for legacy applications
48*	Not used	2	0	0	1.0	0.0	NA	NA	Retained for legacy applications
49*	Not used	2	0	0	1.0	0.0	NA	NA	Retained for legacy applications
50*	Not used	2	0	0	1.0	0.0	NA	NA	Retained for legacy applications
51*	Not used	2	0	0	1.0	0.0	NA	NA	Retained for legacy applications
52*	Not used	2	0	0	1.0	0.0	NA	NA	Retained for legacy applications
53	Active Setting Group Number	2	1	8	1.0	0.0	NA	1.0	

Point Index	Name	Default Class Assigned to Events (1, 2, 3 or none)	Transmitted Value[a]		Scaling[b]		Units	Resolution[c] (default/ maximal)	Description
			Minimum	Maximum[d]	Multiplier (default/ (range))	Offset			
54	Fault Information - DNP Time (High 16 bits)	none	0	65,535	1.0	0.0	NA	1.0	See description below on how to access Fault Information.
55	Fault Information - DNP Time (Middle 16 bits)	none	0	65,535	1.0	0.0	NA	1.0	
56	Fault Information - DNP Time (Low 16 bits)	none	0	65,535	1.0	0.0	NA	1.0	
57	Fault Information - Fault Distance	none	0	Configurable	0.1	0.0	Configurable	0.1	
58	Fault Information - Type	none	0	15	1.0	0.0	NA	1.0	
59	Ia Summated Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
60	Ia Summated Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
61	Ib Summated Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
62	Ib Summated Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
63	Ic Summated Magnitude	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
64	Ic Summated Angle	2	-18,000	18,000	0.1 / (0.01 - 1.0)	0.0	Degrees	0.1 / 0.01	
65	Self check Fail	2	0	65,535	1.0	0.0	NA	1.0	
66	S	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	MVA	0.1 / 0.00001	
67	Power Factor	2	-1000	1000	0.01 / (0.001- 0.1)	0.0	NA	0.01 / 0.001	
68	Voltage (V1)	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	kV	0.1 / 0.00001	
69	Voltage (V0)	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	kV	0.1 / 0.00001	
70	Current (I2)	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
71	Current (I0)	2	0	Configurable	1.0 / (0.01 - 1000)	0.0	A	1.0 / 0.01	
72*	Pa	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	MW	0.1 / 0.00001	
73*	Pb	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	MW	0.1 / 0.00001	
74*	Pc	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	MW	0.1 / 0.00001	
75*	Qa	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	Mvar	0.1 / 0.00001	
76*	Qb	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	Mvar	0.1 / 0.00001	
77*	Qc	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	Mvar	0.1 / 0.00001	
78*	Sa	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	MVA	0.1 / 0.00001	
79*	Sb	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	MVA	0.1 / 0.00001	
80*	Sc	2	0	Configurable	0.1 / (0.00001- 1.0)	0.0	MVA	0.1 / 0.00001	
81*	Power Factor a	2	-1000	1000	0.01 / (0.001- 0.1)	0.0	NA	0.01 / 0.001	
82*	Power Factor b	2	-1000	1000	0.01 / (0.001- 0.1)	0.0	NA	0.01 / 0.001	
83*	Power Factor c	2	-1000	1000	0.01 / (0.001- 0.1)	0.0	NA	0.01 / 0.001	

a. The minimum and maximum transmitted values are the lowest and highest values that the outstation will report in DNP analog input objects. These values are integers if the outstation transmits only integers. If the outstation is capable of transmitting both integers and floating-point, then integer and floating-point values are required for the minimums and maximums.
For example, a pressure sensor is able to measure 0 to 500 kPa. The outstation provides a linear conversion of the sensor's output signal to integers in the range of 0 to 25000 or floating-point values of 0 to 500.000. The sensor and outstation are used in an application where the maximum possible pressure is 380 kPa. For this input, the minimum transmitted value would be stated as 0 / 0.0 and the maximum transmitted value would be stated as 19000 / 380.000.

b. The scaling information for each point specifies how data transmitted in integer variations (16 bit and 32 bit) is converted to engineering units when received by the Master (i.e. scaled according to the equation: scaled value = multiplier * raw + offset). Scaling is not applied to Floating point variations since they are already transmitted in engineering units.

c. Resolution is the smallest change that may be detected in the value due to quantization errors and is given in the units shown in the previous column. This parameter does not represent the accuracy of the measurement.

d. Maximal values are calculated as (2 * Configured Nominal / Multiplier) for voltage channels and as (40 * Configured Nominal / Multiplier) for current channels (see Note 2 above for the nominal definitions).

2.4 Octet String Points Static (Steady-State) Group Number: 110 Event Group Number: 111	**Capabilities**	**Current Value**	**If configurable, list methods**
2.4.1 Event reporting mode *:	☐ Only most recent ☒ All events		
2.4.2 Octet Strings Included in Class 0 response:	☐ Always ☒ Never ☐ Only if point is assigned to Class 1, 2, or 3 ☐ Based on point Index (add column to table below)		
2.4.3 Definition of Octet String Point List:	☐ Fixed, list shown in table below ☐ Configurable (current list may be shown in table below) ☒ Other, explain Used for Event Log access as described below		

* Object 110 and 111 are Octet String Object used to provide access to the Event Log text of the relay. Object 110 always contains the most recent event in the relay. Object 111 is the corresponding change event object.

As stated in the DNP specifications, the variation of the response object represents the length of the string. The string represents the ASCII values of the event text. The first two characters in the string can be used to quickly identify fault location events. Fault locator events begin with the characters "FL" (0x46, 0x4C hex). The following example shows a fault distance event returned through either of the octet string objects:

Event Message:

FL2000Sep21 20:16:16.966: 21P1 AB 1.0km: Trip

DNP Octet string object components:					
0x46	0x4C	0x32	0x30	0x30	0x30
0x53	0x65	0x70	0x32	0x31	0x20
0x32	0x30	0x3A	0x31	0x36	0x3A
0x31	0x36	0x2E	0x39	0x36	0x36
0x20	0x32	0x31	0x50	0x31	0x20
0x41	0x42	0x20	0x31	0x2E	0x30
0x6B	0x6D	0x3A	0x20	0x54	0x72
0x69	0x70				

Implementation Table

The following implementation table identifies which object groups and variations, function codes and qualifiers the device supports in both requests and responses. The Request columns identify all requests that may be sent by a Master, or all requests that must be parsed by an Outstation. The Response columns identify all responses that must be parsed by a Master, or all responses that may be sent by an Outstation.

NOTE

The implementation table must list all functionality required by the device whether Master or Outstation as defined within the DNP3 IED Conformance Test Procedures. Any functionality beyond the highest subset level supported is indicated by highlighted rows. Any Object Groups not provided by an outstation or not processed by a Master are indicated by ~~strikethrough~~ (note these Object Groups will still be parsed).

DNP Object Group & Variation			Request Outstation parses		Response Outstation can issue	
Group Num	**Var Num**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
1	0	Binary Input - Any Variation	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
1	1	Binary Input - Packed format	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
1	2	Binary Input - With flags	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
2	0	Binary Input Event - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
2	1	Binary Input Event - Without time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) ~~130 (unsol. resp)~~	17, 28 (index)
2	2	Binary Input Event - With absolute time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) ~~130 (unsol. resp)~~	17, 28 (index)
2	3	Binary Input Event - With relative time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) ~~130 (unsol. resp)~~	17, 28 (index)
10	0	Binary Output - Any Variation	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
10	2	Binary Output - Output Status with flag	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
12	1	Binary Command - Control relay output block (CROB)	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, no ack)	17, 28 (index)	129 (response)	Echo of request

DNP Object Group & Variation			Request Outstation parses		Response Outstation can issue	
Group Num	**Var Num**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
20	0	~~Counter - Any Variation~~	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack)	06 (no range, or all)	129 (response)	
20	1	~~Counter - 32-bit with flag~~			129 (response)	~~00, 01 (start-stop)~~
20	2	~~Counter - 16-bit with flag~~			129 (response)	~~00, 01 (start-stop)~~
20	5	~~Counter - 32-bit without flag~~			129 (response)	~~00, 01 (start-stop)~~
20	6	~~Counter - 16-bit without flag~~			129 (response)	~~00, 01 (start-stop)~~
21	0	~~Frozen Counter - Any Variation~~	1 (read)	06 (no range, or all)		
21	1	~~Frozen Counter - 32-bit with flag~~			129 (response)	~~00, 01 (start-stop)~~
21	2	~~Frozen Counter - 16-bit with flag~~			129 (response)	~~00, 01 (start-stop)~~
21	9	~~Frozen Counter - 32-bit without flag~~			129 (response)	~~00, 01 (start-stop)~~
21	10	~~Frozen Counter - 16-bit without flag~~			129 (response)	~~00, 01 (start-stop)~~
22	0	~~Counter Event - Any Variation~~	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
22	1	~~Counter Event - 32-bit with flag~~			129 (response) ~~130 (unsol. resp)~~	~~17, 28 (index)~~
22	2	~~Counter Event - 16-bit with flag~~			129 (response) ~~130 (unsol. resp)~~	~~17, 28 (index)~~
30	0	Analog Input - Any Variation	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
30	1	Analog Input - 32-bit with flag	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
30	2	Analog Input - 16-bit with flag	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
30	3	Analog Input - 32-bit without flag	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
30	4	Analog Input - 16-bit without flag	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
32	0	Analog Input Event - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
32	1	Analog Input Event - 32-bit without time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) ~~130 (unsol. resp)~~	17, 28 (index)
32	2	Analog Input Event - 16-bit without time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) ~~130 (unsol. resp)~~	17, 28 (index)
32	3	Analog Input Event - 32-bit with time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
32	4	Analog Input Event - 16-bit with time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
40	0	~~Analog Output Status - Any Variation~~	1 (read)	06 (no range, or all)	129 (response)	

DNP Object Group & Variation			Request Outstation parses		Response Outstation can issue	
Group Num	**Var Num**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
40	2	~~Analog Output Status - 16-bit with flag~~			129 (response)	~~00, 01 (start-stop)~~
41	2	~~Analog Output - 16-bit~~	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, no ack)	17, 28 (index)	129 (response)	~~Echo of request~~
50	1	~~Time and Date - Absolute time~~	2 (write)	07 (limited qty = 1)	129 (response)	
51	1	~~Time and Date CTO - Absolute time, synchronized~~			~~129 (response)~~ ~~130 (unsol. resp)~~	~~07 (limited qty)~~ ~~(qty = 1)~~
51	2	Time and Date CTO - Absolute time, unsynchronized			129 (response) ~~130 (unsol. resp)~~	07 (limited qty) (qty = 1)
52	1	Time Delay - Coarse			129 (response)	07 (limited qty) (qty = 1)
52	2	~~Time delay - Fine~~			~~129 (response)~~	~~07 (limited qty)~~ ~~(qty = 1)~~
60	1	Class Objects - Class 0 data	1 (read)	06 (no range, or all)	129 (response)	00, 01 (start-stop)
60	2	Class Objects - Class 1 data	1 (read)	06 (no range, or all)	129 (response)	17, 28 (index)
60	3	Class Objects - Class 2 data	1 (read)	06 (no range, or all)	129 (response)	17, 28 (index)
60	4	Class Objects - Class 3 data	1 (read)	06 (no range, or all)	129 (response)	17, 28 (index)
80	1	Internal Indications - Packet format	2 (write)	00 (start-stop) (index = 7)	129 (response)	
110	0	Octet string	1 (read)	06 (no range, or all)	129 (response)	07 (limited qty)
111	0	Octet string event	1 (read)	06 (no range, or all)	129 (response)	07 (limited qty)
No Object (function code only)			13 (cold restart)		129 (response)	
No Object (function code only)			14 (warm restart)		129 (response)	
No Object (function code only)			23 (delay meas.)		129 (response)	

Appendix G Mechanical Drawings

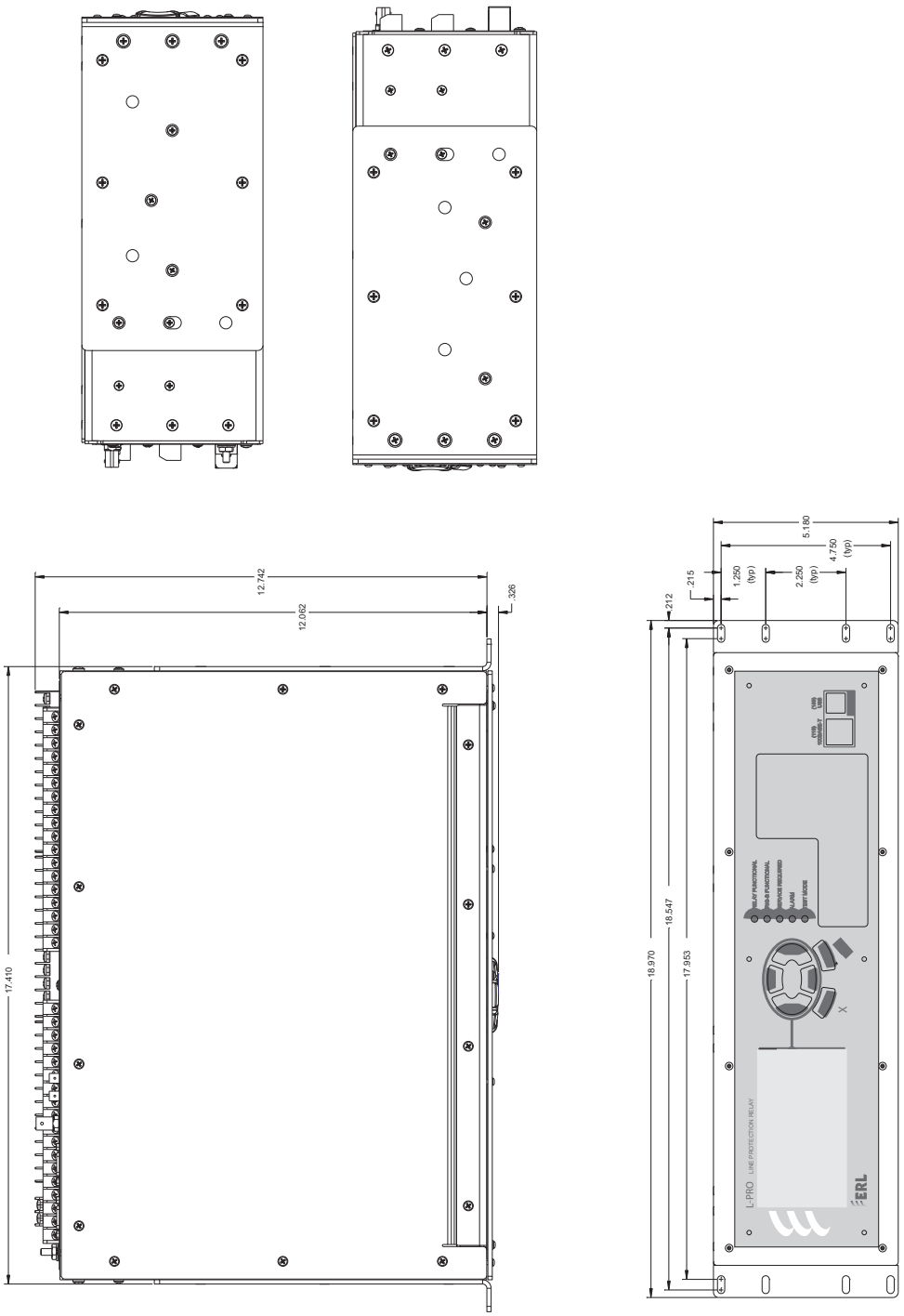


Figure G.1: Mechanical Drawing (3U)

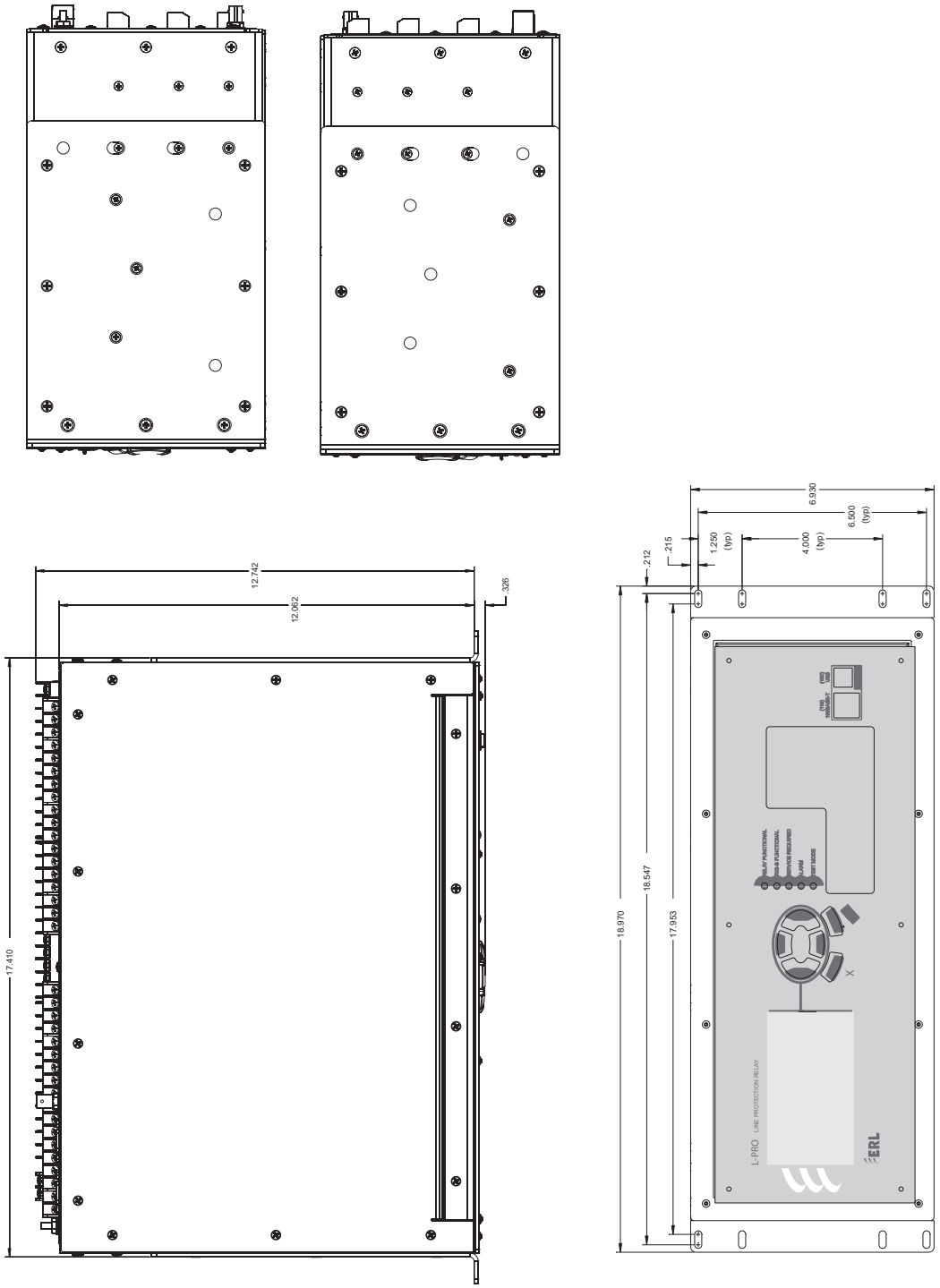


Figure G.1: Mechanical Drawing (4U)

Appendix H Rear Panel Drawings

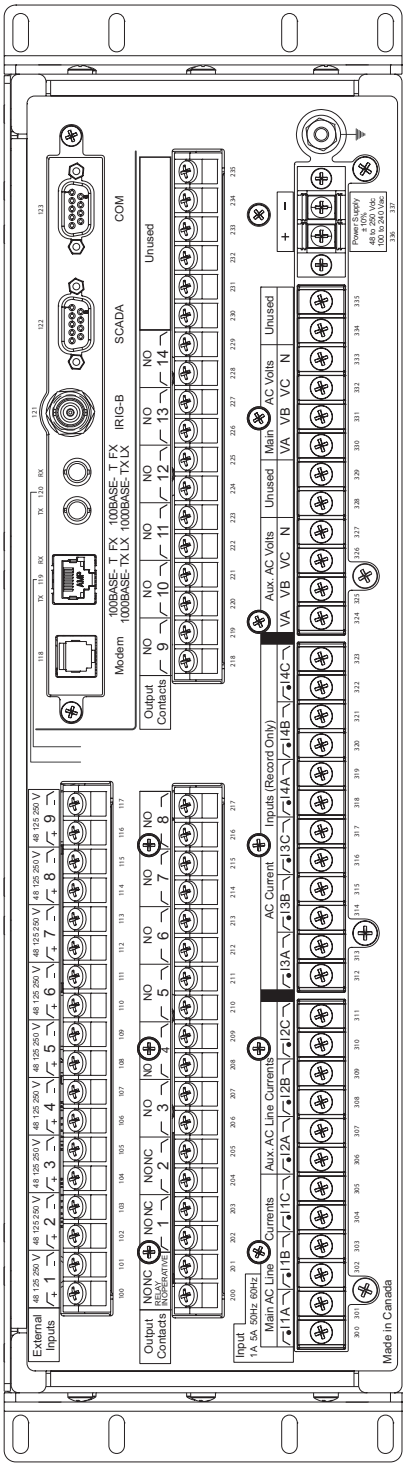


Figure H.1: Rear Panel 3U/3A (previously 3U) Chassis

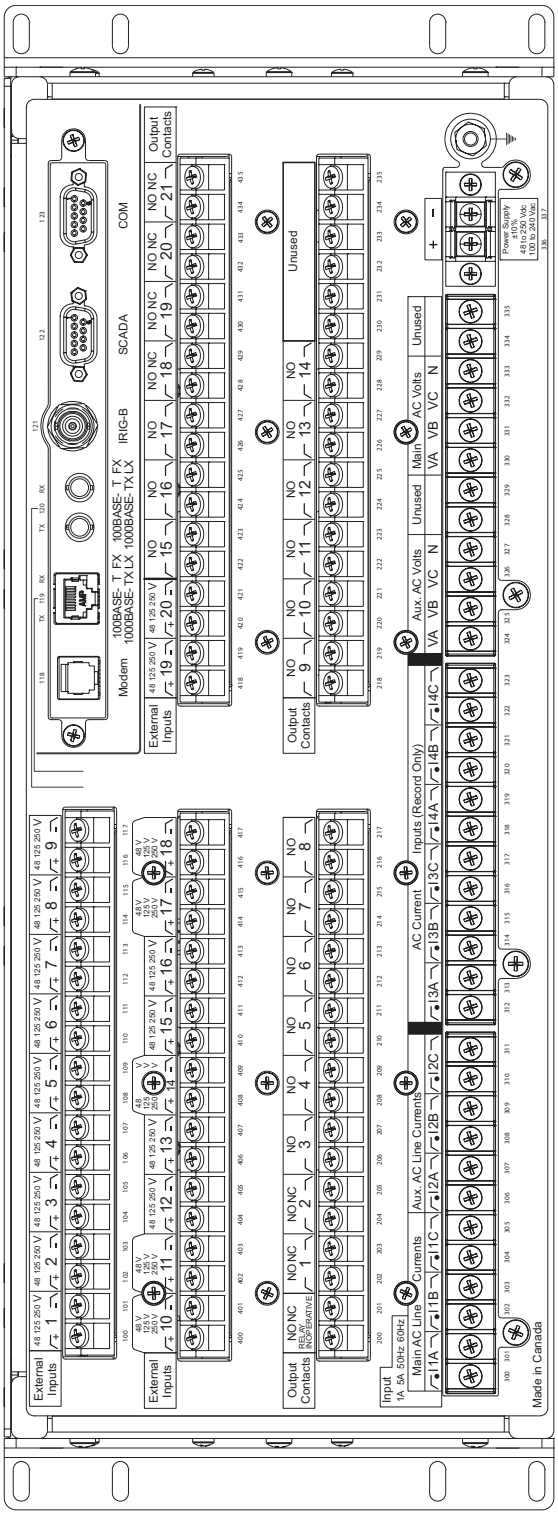


Figure H.2: Rear Panel 4U/4A (previously 4U) Chassis

Appendix I AC Schematic Drawings

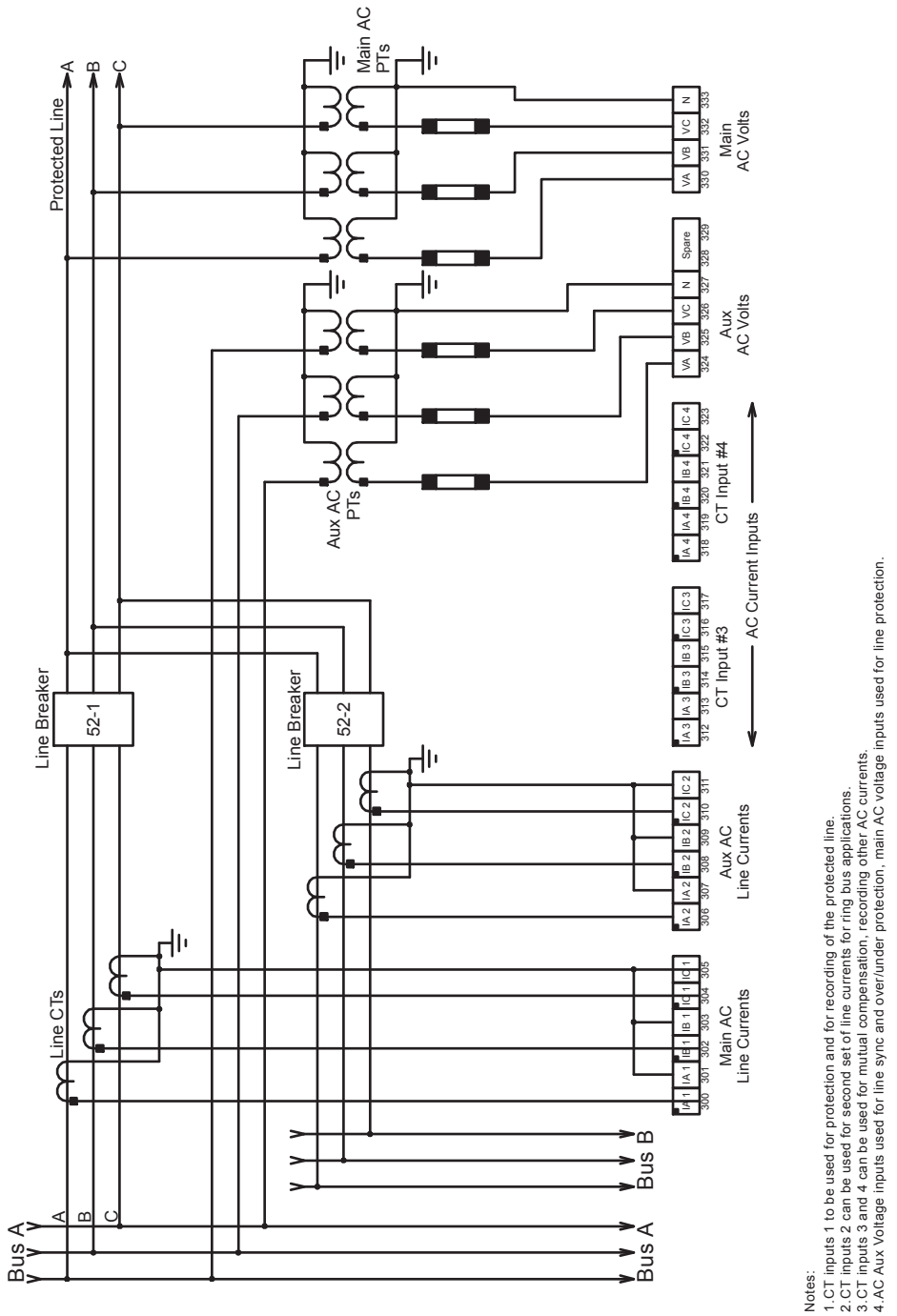

Protected Line
A
B
C
Main AC PTs
Aux AC PTs
Line Breaker
52-1
52-2
Line CTs
Bus A
Bus B
Main AC Line Currents
Aux AC Line Currents
CT Input #3
CT Input #4
AC Current Inputs
Main AC Volts
Aux AC Volts
VA
VB
VC
N
Spare
Notes:
1. CT inputs 1 to be used for protection and for recording of the protected line.
2. CT inputs 2 can be used for second set of line currents for ring bus applications.
3. CT inputs 3 and 4 can be used for mutual compensation, recording other AC currents.
4. AC Aux Voltage inputs used for line sync and over/under protection, main AC voltage inputs used for line protection.

Figure I.1: L-PRO AC Schematic

Appendix J DC Schematic Drawings

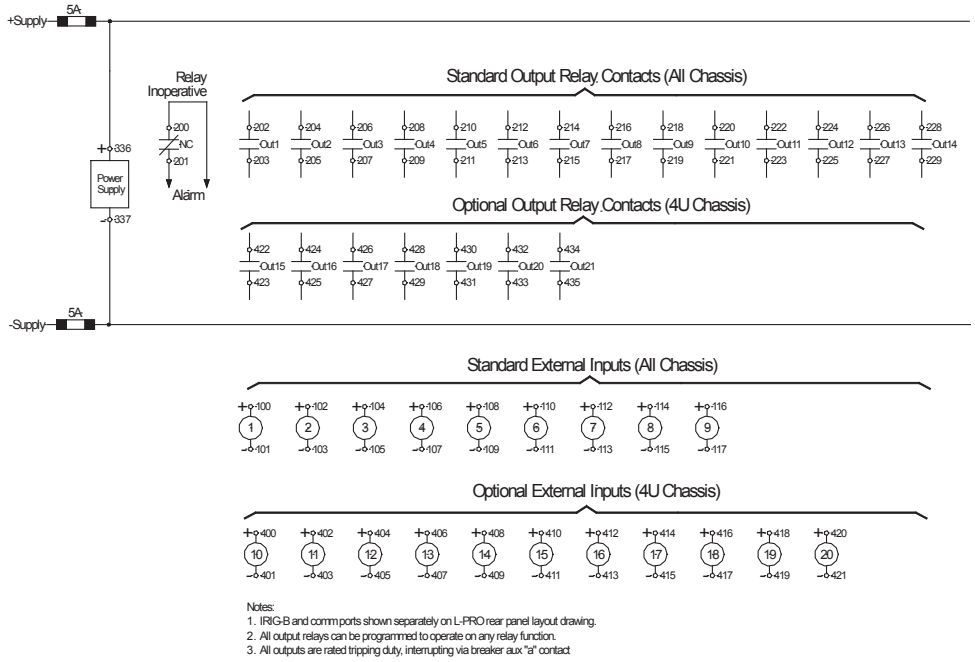

+Supply
5A
-Supply
5A
Relay
Inoperative
200
NC
201
Alarm
336
Power
Supply
337
Standard Output Relay Contacts (All Chassis)
202 204 206 208 210 212 214 216 218 220 222 224 226 228
Out1 Out2 Out3 Out4 Out5 Out6 Out7 Out8 Out9 Out10 Out11 Out12 Out13 Out14
203 205 207 209 211 213 215 217 219 221 223 225 227 229
Optional Output Relay Contacts (4U Chassis)
422 424 426 428 430 432 434
Out15 Out16 Out17 Out18 Out19 Out20 Out21
423 425 427 429 431 433 435
Standard External Inputs (All Chassis)
100 102 104 106 108 110 112 114 116
1 2 3 4 5 6 7 8 9
101 103 105 107 109 111 113 115 117
Optional External Inputs (4U Chassis)
400 402 404 406 408 410 412 414 416 418 420
10 11 12 13 14 15 16 17 18 19 20
401 403 405 407 409 411 413 415 417 419 421
Notes:
1. IRIG-B and comm ports shown separately on L-PRO rear panel layout drawing.
2. All output relays can be programmed to operate on any relay function.
3. All outputs are rated tripping duty, interrupting via breaker aux "a" contact

Figure J.1: L-PRO DC Schematic

Appendix K Function Logic Diagram

Diagram in plastic sleeve.

Appendix L L-PRO Setting Example

Protection, Timers and I/O Status

The relay does not block any protection functions or external inputs during the setting save or active group change, but the external output contacts are reset for one cycle.

The relay applies the setting parameters, resets all protection functions, resets all timers and continues to process the protection algorithms but does not apply any action to the output contacts for one cycle. For close-in (heavy) fault conditions that occur at the time of a setting change the relay performance has a maximum increase in output delay of one cycle. For light fault conditions the relay performance does not have a noticeable change. There is normally a one cycle decision making process of operating time. When the relay algorithms determine that a fault is present, tripping will occur after a one cycle delay. It will take an additional 3 ms to actually close the output tripping contacts.

Latch Status

The relay does not reset any ProLogic, Group Logic or Virtual Input latch functions during the setting save or active group change. Retaining latch status allows the relay continuous access to specific latched logic states. This is useful when the relay has ProLogic, Group Logic or Virtual Input functions used to block protection or ancillary functions for specific operating conditions.

Event Status Reset

The relay resets all the events that are currently high and reports states of all the events that remain high after a setting change.

Viewing Active Setting Group

To view the active setting group and status of the group logic functions in real time via the TUI, enter the *Metering/Logic/Setting Group* menu choice. To view a snapshot of the group logic data, enter the *Settings/Active Group* menu choice.

Front Panel Active Setting Group

The front panel display along with the front panel control buttons allow the user to access metering and setting functions within the relay.

The front display also allows the user to reset the LED target lights that will occur if a relay trip occurs. The front display will go dark and reset if no user interaction has taken place for a period of time. Pressing any of the front panel control buttons brings the front panel to life.

L.1 Switching Setting Groups

The user can program a total of 16 Group Logic statements per setting group to cause a setting change from one group to another. Create settings using the *Offliner* setting software or by using the Terminal Mode.

Some common uses for setting groups might be cold load pickup, Zone 1 and/or Zone 2 reach extension for phase and ground distance elements, zero sequence source increase or decrease.

An example of pulsing an external input and an example of a solid initiate to activate setting group changes are shown below.

Using One External Input to Toggle Setting Group

Use one external input connected to a SCADA output contact to toggle between 2 or more setting groups. In this example we connect external input one (EI 1) to the SCADA control output contact and switch between group 1 and group 2. If the user wanted to switch through all setting groups, group logic 2 would switch to setting group 3, and so forth. If the contact input to switch setting groups becomes welded shut or the SCADA system has a problem, the relay will only switch to the new logic and stay in that logic until the input has been de-energized for the ProLogic pickup delay, which was set to 10 seconds.

Setting Group 1 – Logic Statements

When setting group one becomes active either through a setting group change or is the default group after relay power up, ProLogic 9 becomes high after the 10.00 second delay, if EI 1 is low. ProLogic 9 is set for a 0.26 second dropout time; to be used with ProLogic 10 dropout timer allowing for the slower processing thread where Group Logic is processed and providing a definite timed pulse to the group logic.

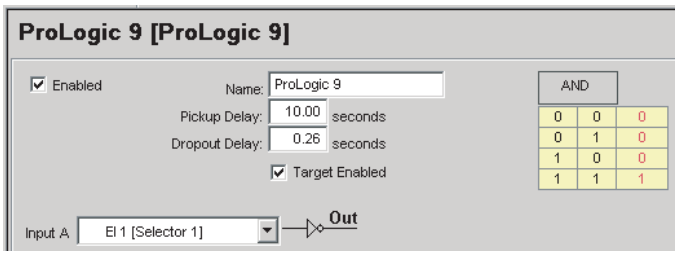


Figure L.1: ProLogic 9

Prologic 10 has no intentional delay and becomes high for the combined drop-out time of ProLogic 9 and 10 equalling 0.52 seconds.

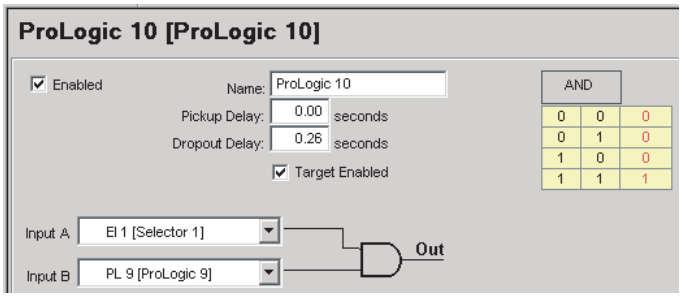


Figure L.2: ProLogic 10

Group Logic 1 is used to switch to the new setting group; there is no intentional delay. The user can also provide 4 additional logic inputs to be used to provide qualifiers before switching setting groups. The example uses a ProLogic statement and an external input as qualifiers, see example “Using ProLogic to Qualify Group Logic Statements” in Appendix L’ on page Appendix L-8.

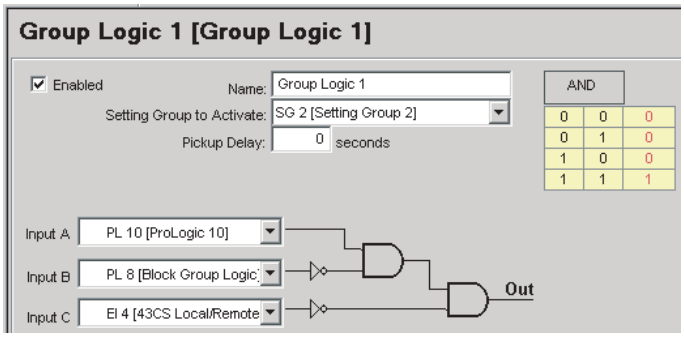

Group Logic 1 [Group Logic 1]
Enabled
Name: Group Logic 1
Setting Group to Activate: SG 2 [Setting Group 2]
Pickup Delay: 0 seconds
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A PL 10 [ProLogic 10]
Input B PL 8 [Block Group Logic:
Input C EI 4 [43CS Local/Remote
Out

Figure L.3: Group Logic 1

Setting Group 2 – Logic Statements

When setting group 2 becomes active either through a setting group change or is the default group after relay power up, ProLogic 9 becomes high after the 10.00 second delay, if external input one is low. The example shows ProLogic 9 set for a 0.26 second dropout time to be used with ProLogic 10 dropout timer allowing for the slower processing thread where Group Logic is processed and providing a definite timed pulse to the group logic.

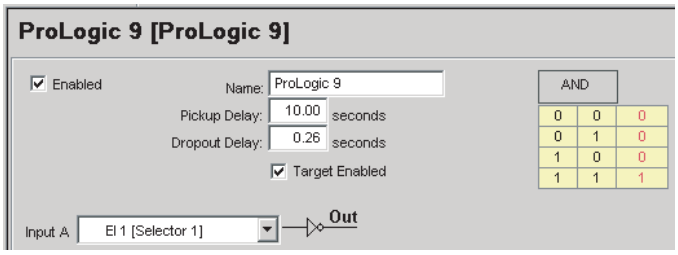


Figure L.4: ProLogic 9

Prologic 10 has no intentional delay and becomes high for the combined drop-out time of ProLogic 9 and 10 equalling 0.52 seconds.

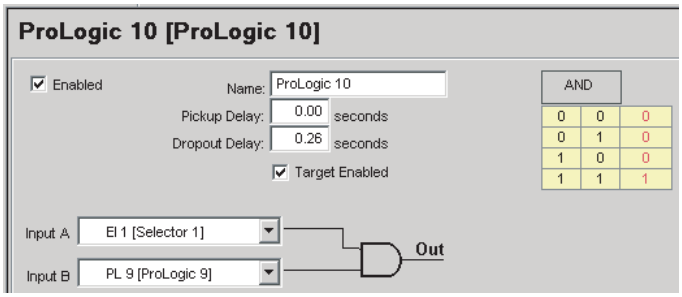


Figure L.5: ProLogic 10

Group Logic 1 is used to switch to the new setting group; there is no intentional delay.

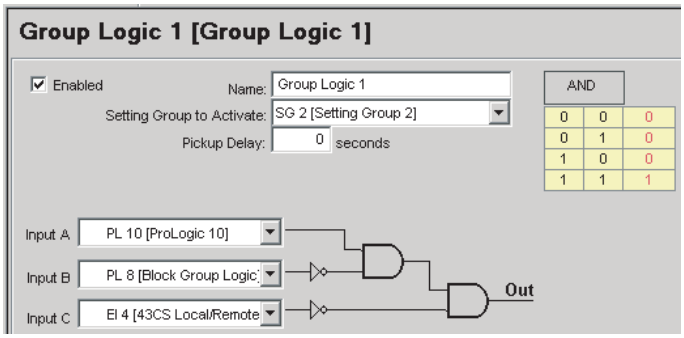


Figure L.6: Group Logic 1

Using Three External Inputs to Toggle Setting Group

Three external inputs connected to an 8 position selector switch. The output contact is used to build a truth table to toggle between 8 setting groups. In this example we connect EI 1, EI 2, and EI 3 to the selector switch output contacts.

Selector Switch	Input States			Setting Group to Activate
	EI 3	EI 2	EI 1	
1	0	0	0	Setting Group 1
2	0	0	1	Setting Group 2
3	0	1	0	Setting Group 3
4	0	1	1	Setting Group 4
5	1	0	0	Setting Group 5
6	1	0	1	Setting Group 6
7	1	1	0	Setting Group 7
8	1	1	1	Setting Group 8

Setting Group 1…8 – Logic Statements

The following Group Logic statements are entered into each of the 8 setting groups.

When the selector switch is rotated to the appropriate position the corresponding setting group becomes active. Each setting group logic can have a specific time delay pickup setting. The user can also provide 2 additional logic inputs in each statement to be used to provide qualifiers before switching setting groups. We are using a ProLogic statement and an external input as qualifiers, see “Using ProLogic to Qualify Group Logic Statements” in Appendix L’ on page Appendix L-8.

EI 1 low, EI 2 low, and EI 3 low

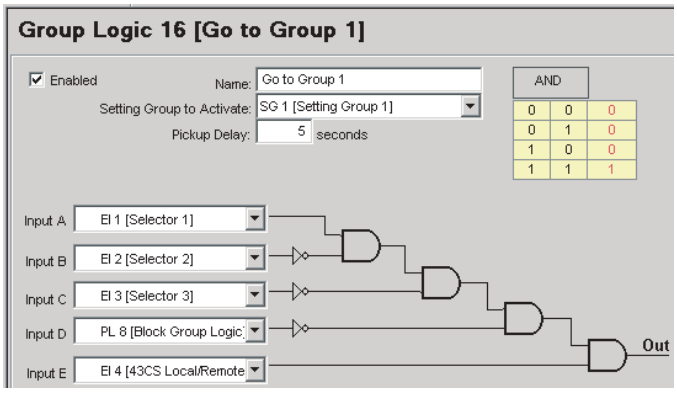

Group Logic 16 [Go to Group 1]
Enabled
Name: Go to Group 1
Setting Group to Activate: SG 1 [Setting Group 1]
Pickup Delay: 5 seconds
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A EI 1 [Selector 1]
Input B EI 2 [Selector 2]
Input C EI 3 [Selector 3]
Input D PL 8 [Block Group Logic
Input E EI 4 [43CS Local/Remote
Out

Figure L.7: Group Logic 16

EI 1 high, EI 2 low, and EI 3 low

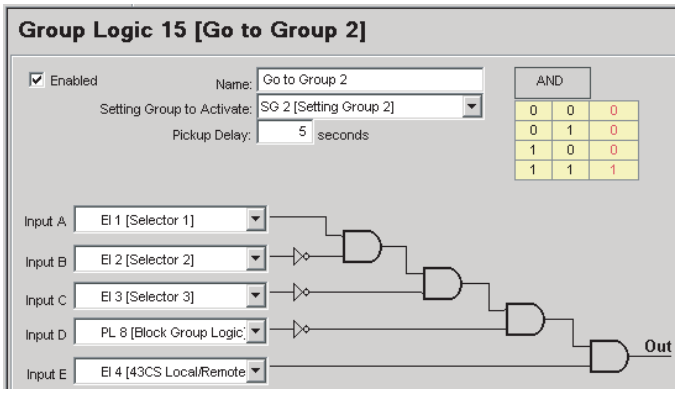

Group Logic 15 [Go to Group 2]
Enabled
Name: Go to Group 2
Setting Group to Activate: SG 2 [Setting Group 2]
Pickup Delay: 5 seconds
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A EI 1 [Selector 1]
Input B EI 2 [Selector 2]
Input C EI 3 [Selector 3]
Input D PL 8 [Block Group Logic
Input E EI 4 [43CS Local/Remote
Out

Figure L.8: Group Logic 15

EI 1 low, EI 2 high, and EI 3 low

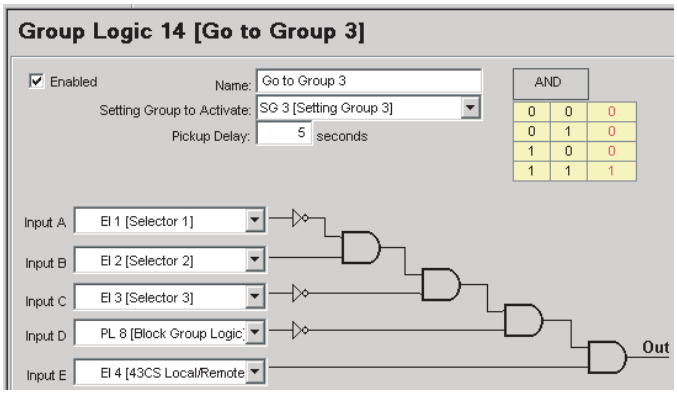

Group Logic 14 [Go to Group 3]
Enabled
Name: Go to Group 3
Setting Group to Activate: SG 3 [Setting Group 3]
Pickup Delay: 5 seconds
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A EI 1 [Selector 1]
Input B EI 2 [Selector 2]
Input C EI 3 [Selector 3]
Input D PL 8 [Block Group Logic
Input E EI 4 [43CS Local/Remote
Out

Figure L.9: Group Logic 14

EI 1 high, EI 2 high, and EI 3 low

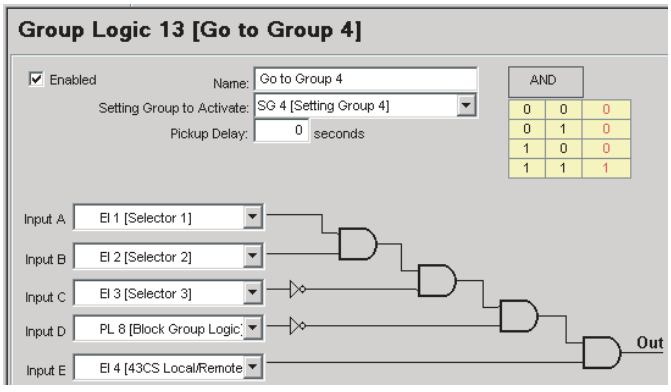

Group Logic 13 [Go to Group 4]
Enabled
Name: Go to Group 4
Setting Group to Activate: SG 4 [Setting Group 4]
Pickup Delay: 0 seconds
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A EI 1 [Selector 1]
Input B EI 2 [Selector 2]
Input C EI 3 [Selector 3]
Input D PL 8 [Block Group Logic
Input E EI 4 [43CS Local/Remote
Out

Figure L.10: Group Logic 13

EI 1 low, EI 2 low, and EI 3 high

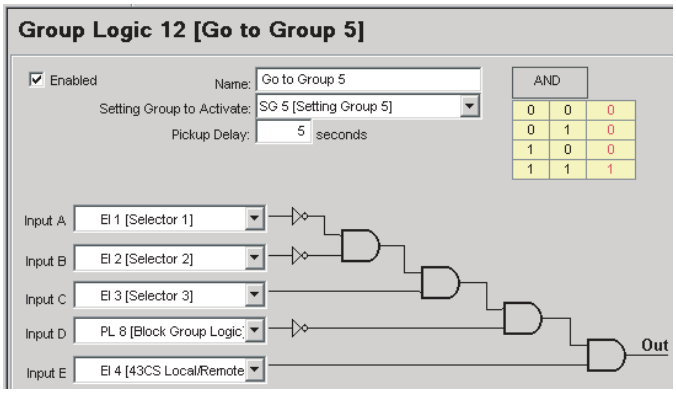

Group Logic 12 [Go to Group 5]
Enabled
Name: Go to Group 5
Setting Group to Activate: SG 5 [Setting Group 5]
Pickup Delay: 5 seconds
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A EI 1 [Selector 1]
Input B EI 2 [Selector 2]
Input C EI 3 [Selector 3]
Input D PL 8 [Block Group Logic
Input E EI 4 [43CS Local/Remote
Out

Figure L.11: Group Logic 12

EI 1 high, EI 2 low, and EI 3 high

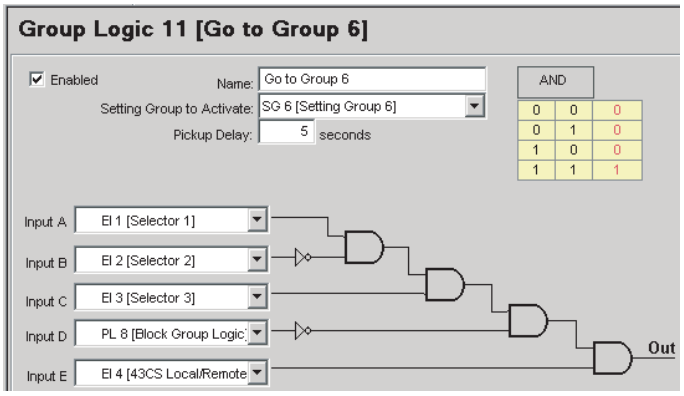

Group Logic 11 [Go to Group 6]
Enabled
Name: Go to Group 6
Setting Group to Activate: SG 6 [Setting Group 6]
Pickup Delay: 5 seconds
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A EI 1 [Selector 1]
Input B EI 2 [Selector 2]
Input C EI 3 [Selector 3]
Input D PL 8 [Block Group Logic
Input E EI 4 [43CS Local/Remote
Out

Figure L.12: Group Logic 11

EI 1 low, EI 2 high, and EI 3 high

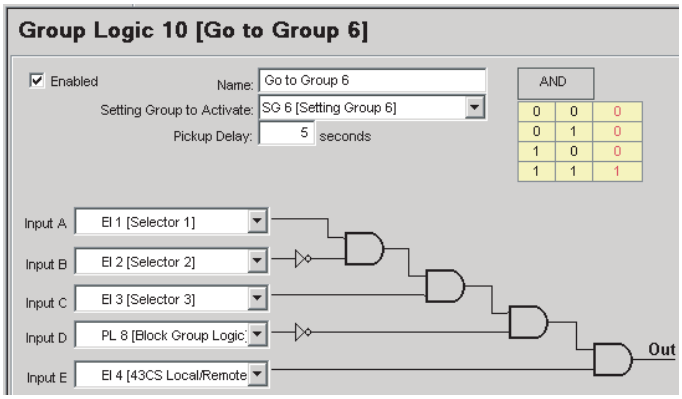

Group Logic 10 [Go to Group 6]
Enabled
Name: Go to Group 6
Setting Group to Activate: SG 6 [Setting Group 6]
Pickup Delay: 5 seconds
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A EI 1 [Selector 1]
Input B EI 2 [Selector 2]
Input C EI 3 [Selector 3]
Input D PL 8 [Block Group Logic
Input E EI 4 [43CS Local/Remote
Out

Figure L.13: Group Logic 10

EI 1 high, EI 2 high, and EI 3 high

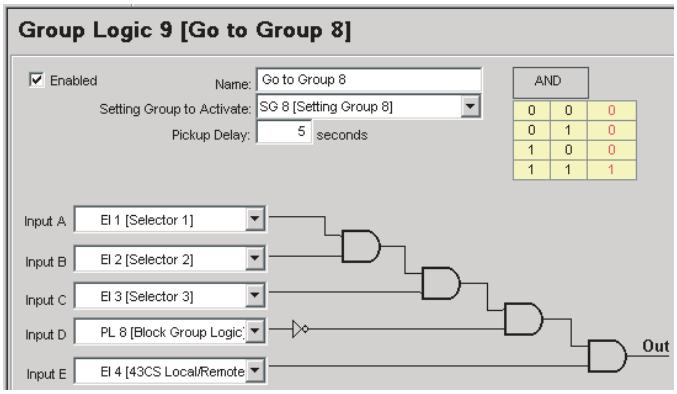

Group Logic 9 [Go to Group 8]
Enabled
Name: Go to Group 8
Setting Group to Activate: SG 8 [Setting Group 8]
Pickup Delay: 5 seconds
AND
0 0 0
0 1 0
1 0 0
1 1 1
Input A EI 1 [Selector 1]
Input B EI 2 [Selector 2]
Input C EI 3 [Selector 3]
Input D PL 8 [Block Group Logic]
Input E EI 4 [43CS Local/Remote]
Out

Figure L.14: Group Logic 9

Using ProLogic to Qualify Group Logic Statements

Select from any available ProLogic inputs to make specific blocking logic to be used as a qualifier for any group logic decisions. In this example we use either the zone 1 or zone 2 phase distance elements or the communications trip or the communications send or the Power Swing outer blinder alarm to drive the Block Group Logic statement. There is no intentional pickup delay and 0.5 second drop-out delay to hold the block on after the block condition has reset.

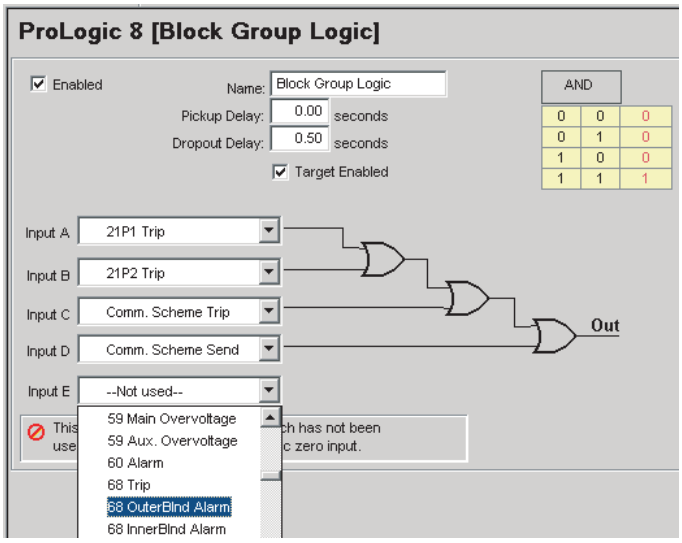


Figure L.15: ProLogic 8

L.2 79 Auto-recloser Examples

The user can program up to 4 shots or reclose attempts with the 79 function, with various lead and follow breaker options. Create settings by using the Offliner settings software or by using the Relay Control Panel.

79 Recloser Settings

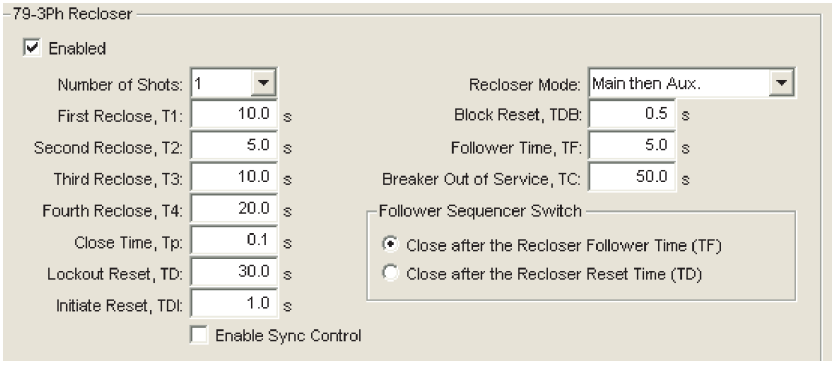

79-3Ph Recloser
Enabled
Number of Shots: 1
First Reclose, T1: 10.0 s
Second Reclose, T2: 5.0 s
Third Reclose, T3: 10.0 s
Fourth Reclose, T4: 20.0 s
Close Time, Tp: 0.1 s
Lockout Reset, TD: 30.0 s
Initiate Reset, TDI: 1.0 s
Enable Sync Control
Recloser Mode: Main then Aux.
Block Reset, TDB: 0.5 s
Follower Time, TF: 5.0 s
Breaker Out of Service, TC: 50.0 s
Follower Sequencer Switch
Close after the Recloser Follower Time (TF)
Close after the Recloser Reset Time (TD)

Figure L.16: 79 Recloser

Setting the recloser is all done in one screen.

In our example we are using one shot with an open interval of 10 seconds (T1) for the Main circuit breaker and a follow interval of 5 seconds (TF) for the auxiliary circuit breaker. This means that 10 seconds after both breakers open the main breaker will attempt to reclose and 5 seconds after the main breaker has closed the auxiliary breaker will attempt to close. The main and auxiliary close signal time is set to last for 0.5 seconds (TP). When the recloser receives an initiation signal that signal will stay high for an additional time of 1.0 seconds which allows the recloser to seal-in (TDI).

We are not using sync control is this example. If sync control was necessary the user only has to enable sync control and then set the appropriate settings in the 25/27/59 screen. For example if Dead Main Dead Auxiliary was selected the recloser would be blocked unless both main and auxiliary voltages are below 20 V (positive sequence).

The recloser mode setting is related to the Ring Bus Configuration (auxiliary CT line input) and must match the breaker configuration in the system parameters screen.

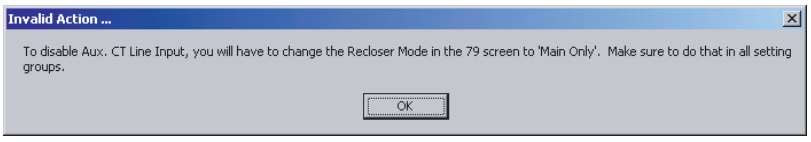

Invalid Action ...
To disable Aux. CT Line Input, you will have to change the Recloser Mode in the 79 screen to 'Main Only'. Make sure to do that in all setting groups.
OK

Figure L.17: Invalid Action

Most protection schemes require the ability to block the 79 when certain events happen. In our example we are using Virtual Input 7 (VI 7) to block. The 79 blocking is set to last for an additional time of 1.0 seconds (TDB).

79 initiation is done by simply setting the desired function in the output matrix.

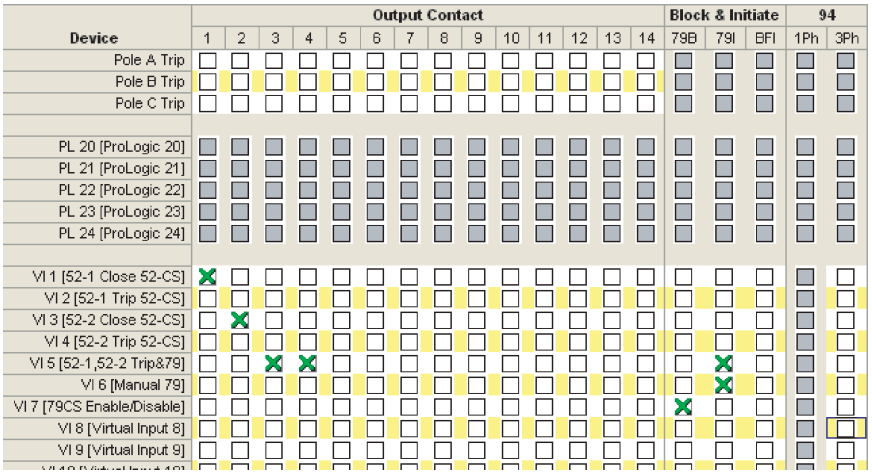

Output Contact
Block & Initiate
94
Device
1 2 3 4 5 6 7 8 9 10 11 12 13 14
79B 79I BFI
1Ph 3Ph
Pole A Trip
Pole B Trip
Pole C Trip
PL 20 [ProLogic 20]
PL 21 [ProLogic 21]
PL 22 [ProLogic 22]
PL 23 [ProLogic 23]
PL 24 [ProLogic 24]
VI 1 [52-1 Close 52-CS]
VI 2 [52-1 Trip 52-CS]
VI 3 [52-2 Close 52-CS]
VI 4 [52-2 Trip 52-CS]
VI 5 [52-1,52-2 Trip&79]
VI 6 [Manual 79]
VI 7 [79CS Enable/Disable]
VI 8 [Virtual Input 8]
VI 9 [Virtual Input 9]

Figure L.18: Output Matrix

The 79 can also automatically move the follow breaker into the lead position if the lead breaker has been out of service for an extended period of time. The out of service indication is also used to prevent reclosing attempts to the main or auxiliary breaker. In our example a breaker has to be opened and stay open for a time of 120.0 seconds (TC).

The 79 can also be configured with the follow breaker switch setting. In this example we are using the TF follow time of 5.0 seconds for the 2nd breaker open interval. The user can use the recloser reset time of TD by selecting the “close after recloser reset time” setting.

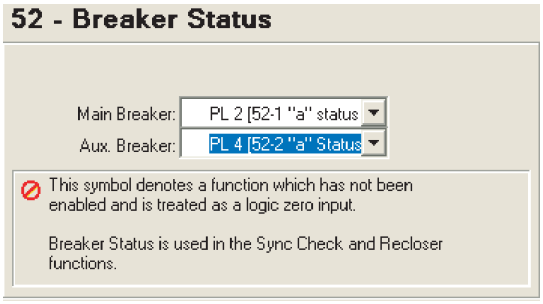

52 - Breaker Status
Main Breaker:
PL 2 [52-1 "a" status
Aux. Breaker:
PL 4 [52-2 "a" Status
This symbol denotes a function which has not been enabled and is treated as a logic zero input.
Breaker Status is used in the Sync Check and Recloser functions.

Figure L.19: Breaker Status

52 - Breaker Status can use any external input or ProLogic statement. The recloser does not have to be enabled for this logic to work. The 2 circuit breakers cannot share the same input.

Figure L.20: Invalid Selection

Test Configuration

Examples to test the 79 functions using Virtual Inputs and ProLogic to simulate the reclose initiation and breaker contact "a" status are shown below.

Virtual Inputs are multi-use logic points that are accessed remotely via SCADA control and/or locally via the Terminal User Interface (TUI).

We will set up 6 virtual inputs to trip and close each breaker and to initiate the 79. External inputs to provide the breaker "a", trip, close, and initiate signals can be used, but using virtual inputs and ProLogic testing is quicker and does not require an external dc supply or relays to simulate the circuit breakers.

Virtual Inputs

The Virtual Input (VI) names are used for descriptive purposes. This name will appear in the event log when the logic point becomes active. The relay supports 2 circuit breakers and in this example we will name the main circuit breaker 52-1 and the auxiliary circuit breaker 52-2. Virtual Inputs 1, 2, 3, and 4 will be used as Control Switches (CS) for tripping and closing while Virtual Input 7 will be used to enable or disable the 79. Virtual Input 5 is used to trip circuit breakers 52-1 and 52-2, and to provide recloser initiation. Virtual Input 6 is used to provide recloser initiation without any tripping (used to help test logic)

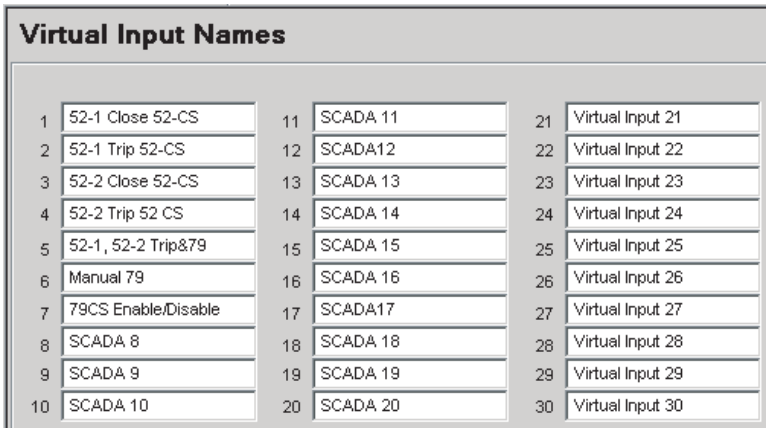


Figure L.21: Virtual Inputs

Main and Auxiliary Circuit Breaker Trip Logic

ProLogic statement 1 and 3 are used to provide a common tripping logic point for the circuit breaker this is analogous to creating a dc trip bus to gather the trip and no reclose or trip and reclose signals. VI2 and VI4 are (VI2 for main and VI4 for auxiliary) the trip and no reclose while VI5 is the trip and reclose (common to main and auxiliary) signal.

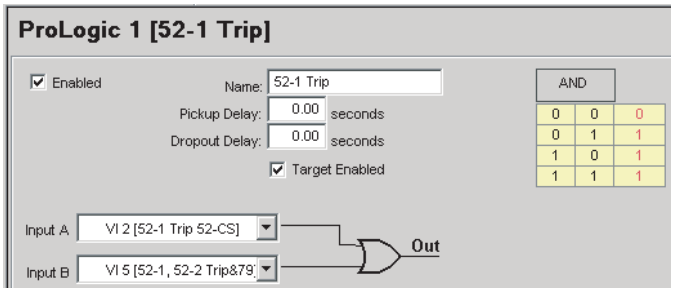


Figure L.22: ProLogic 1 – 52-1 Trip

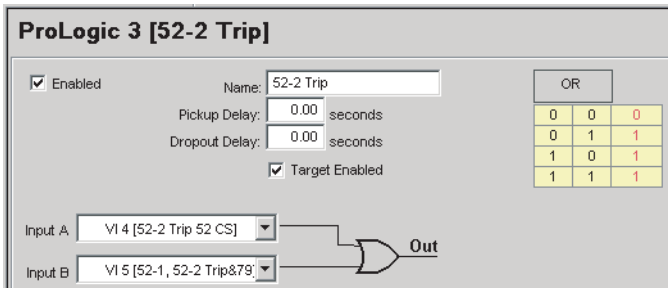


Figure L.23: ProLogic 3 – 52-2 Trip

Circuit Breaker Simulator Logic

ProLogic statement 2 and 4 are used to provide a simulated logic point for the circuit breaker contact “a” status. The output of this logic is used as the input for the 52 - Breaker Status (see 79 Recloser Settings). The 79 Main Reclose logic point and VI1 provide the close signal ProLogic 1 provides the trip signal. The pickup and dropout time delays are used to simulate breaker tripping and closing times.

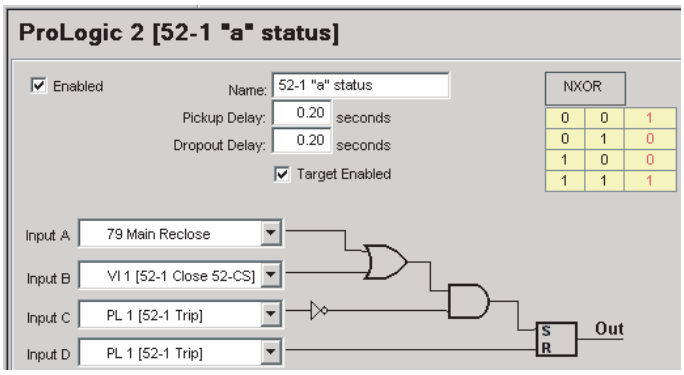


Figure L.24: ProLogic 2 – 52-1 “a” Status

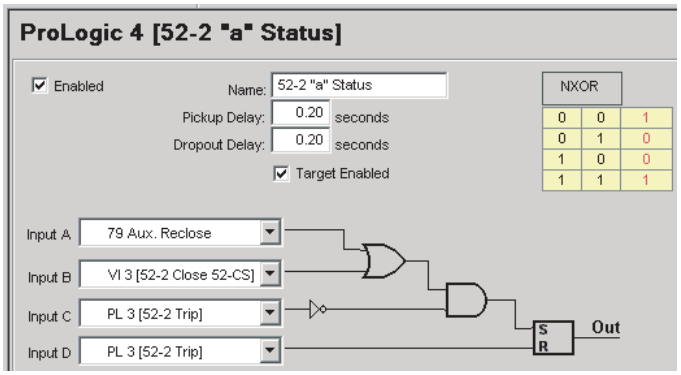


Figure L.25: ProLogic 4 – 52-2 “a” Status

Testing the 79 Recloser

1 Apply the previous settings to the relay.

2 Set PL9 to:

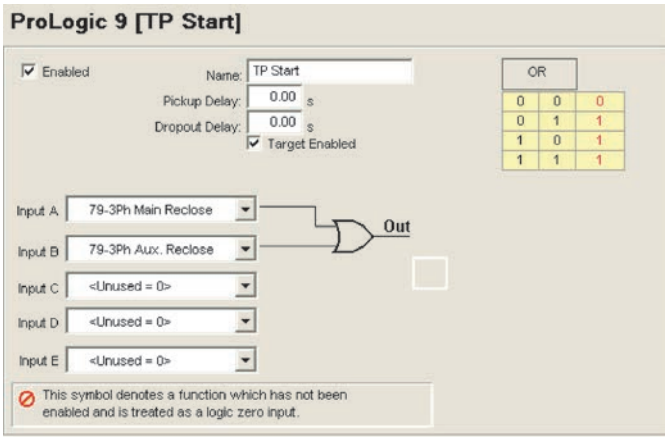


Figure L.26: ProLogic 9 - TP Start

3 Set PL10 to:

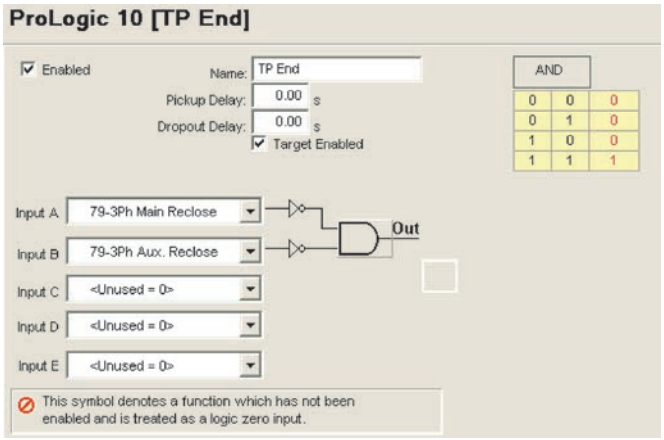


Figure L.27: ProLogic 10 - TP End

4 Set PL6 to:
(used for monitoring purposes)

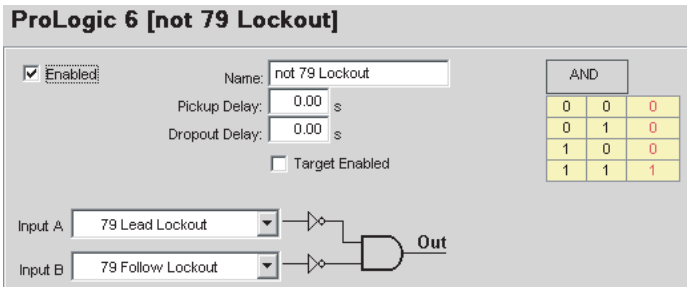


Figure L.28: ProLogic 6 - not 79 Lockout

5 Clear the event log.

6 Check the metering screen for ProLogic. 52-1 and 52-2 should be low.

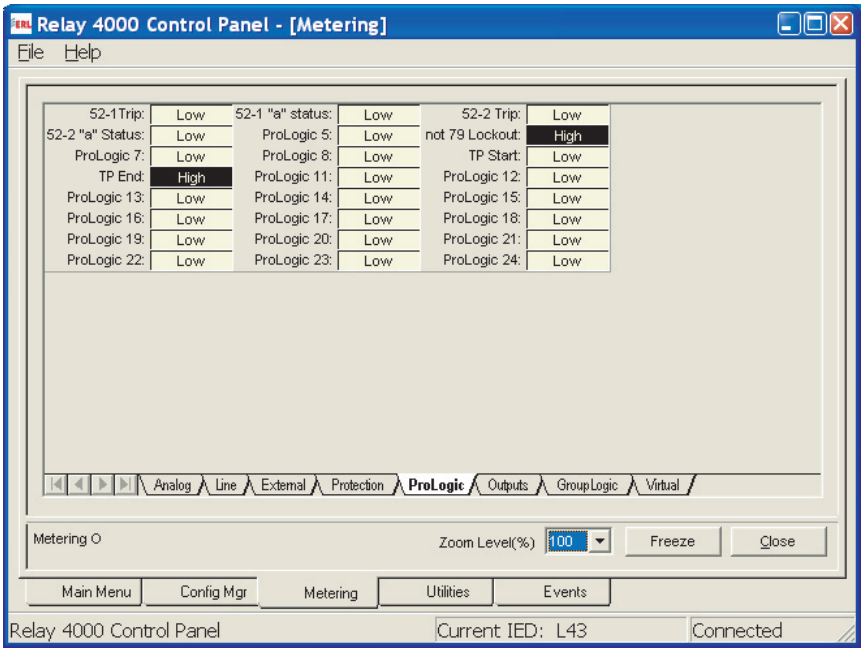


Figure L.29: ProLogic status for 52-1 and 52-2 are low

7 Check the metering screen for Protection. All 79 logic points should be low.

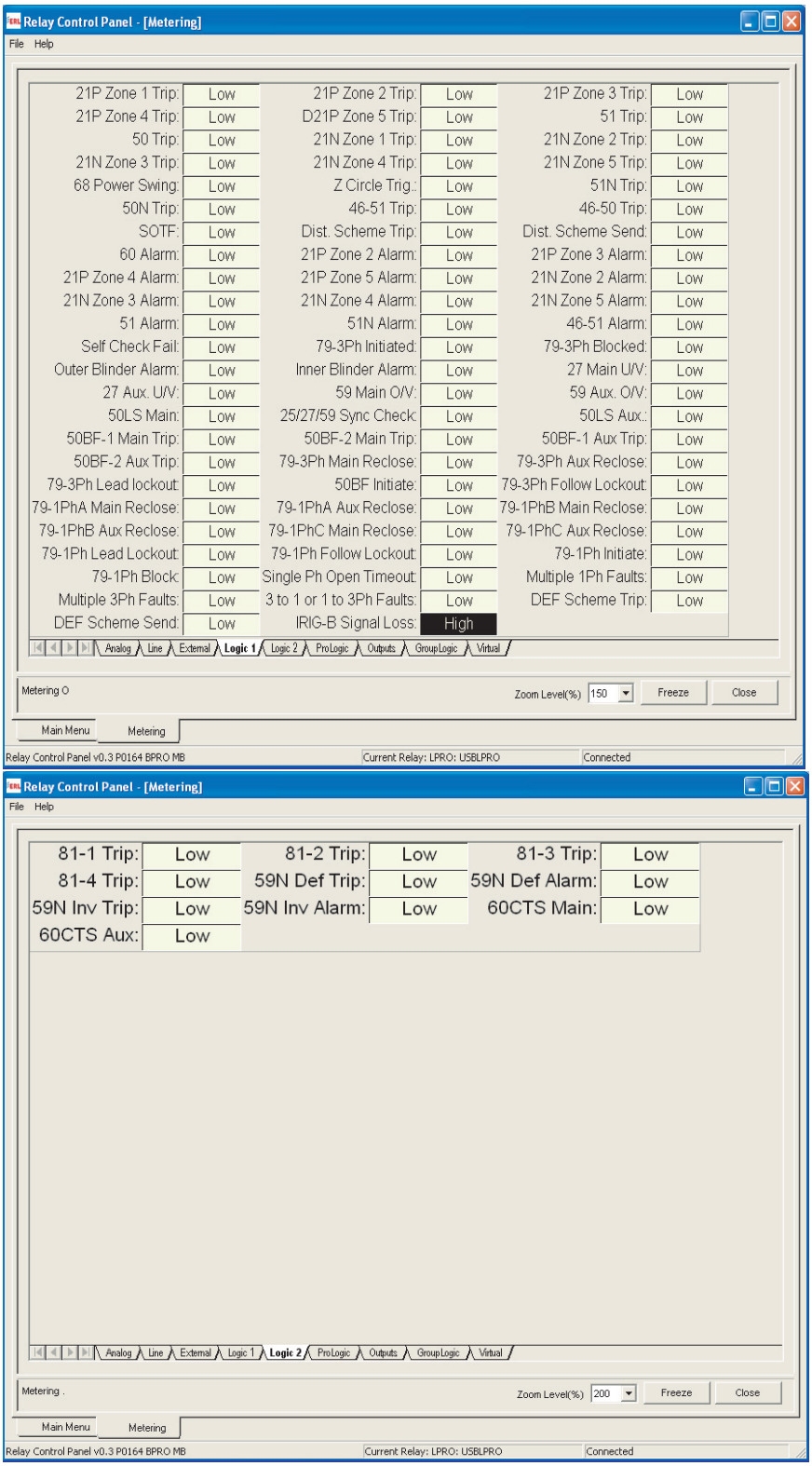


Figure L.30: Protection Metering Screen

8 Go to the Control Virtual Inputs and “close” 52-1 and 52-2 using the Pulse On action for the Virtual Input 1 and Virtual Input 2. This will activate Pro-Logic 2 and 4.

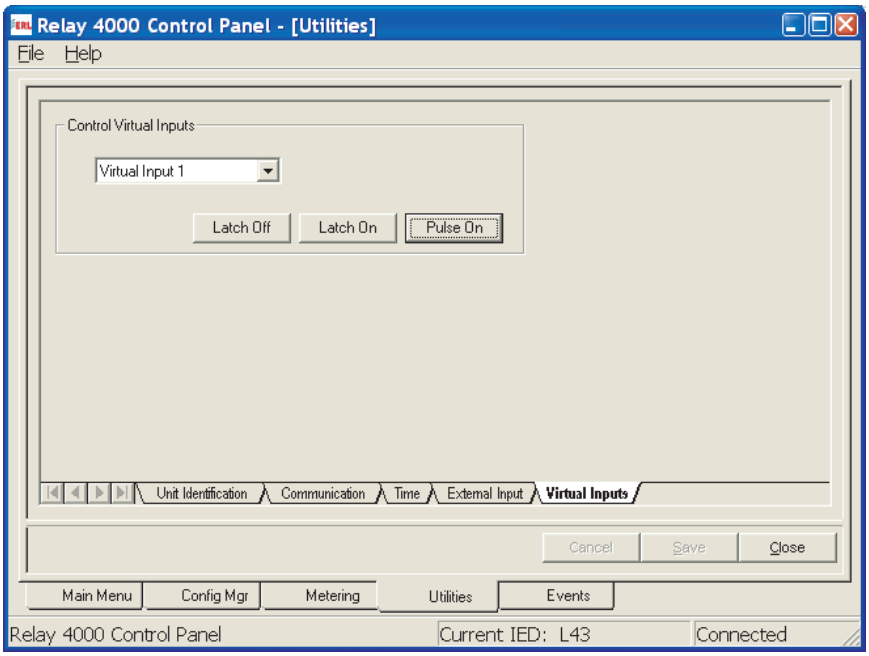


Figure L.31: Control Virtual Input '52-1 Close 52-CS' to 'Pulse On'

9 Check the event log for VI1 and VI3 along with PL2 and PL4.

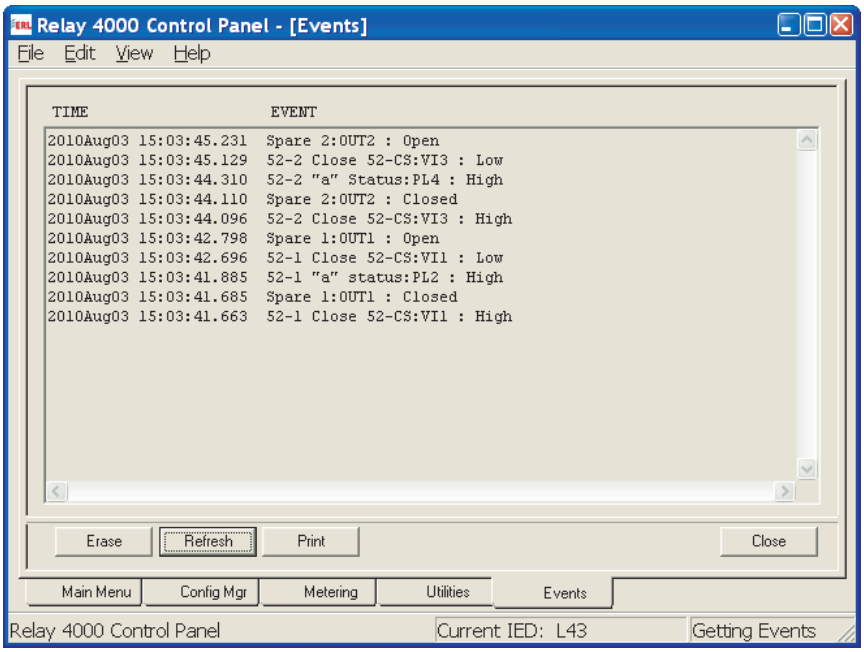


Figure L.32: '52-1 a status: High 'and '52-2 a status: High'

10 Go to the Control Virtual Inputs and select “Manual 79 I” using the Pulse On action for the Virtual Input 6. This will initiate the recloser but no action will be taken because the circuit breakers remain closed.

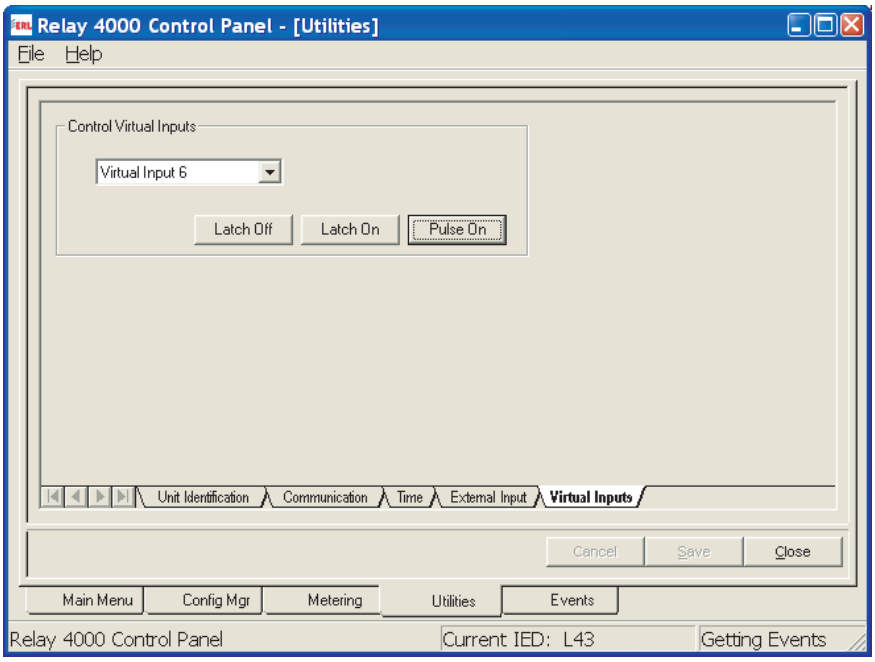


Figure L.33: Pulse On 'Manual 79'

11 Check the event log and confirm there was no reclosure action.

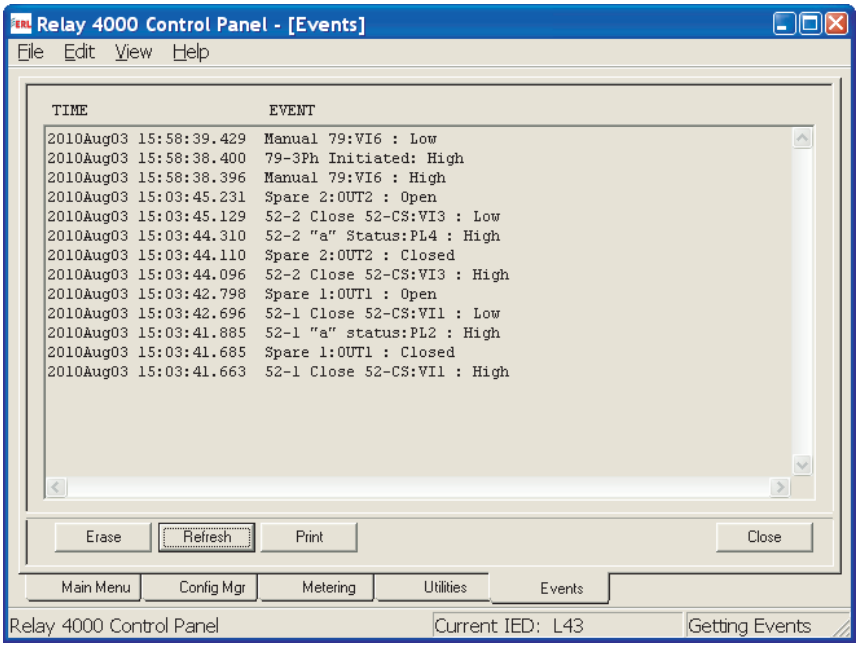

Relay 4000 Control Panel - [Events]
File Edit View Help
TIME EVENT
2010Aug03 15:58:39.429 Manual 79:VI6 : Low
2010Aug03 15:58:38.400 79-3Ph Initiated: High
2010Aug03 15:58:38.396 Manual 79:VI6 : High
2010Aug03 15:03:45.231 Spare 2:OUT2 : Open
2010Aug03 15:03:45.129 52-2 Close 52-CS:VI3 : Low
2010Aug03 15:03:44.310 52-2 "a" Status:PL4 : High
2010Aug03 15:03:44.110 Spare 2:OUT2 : Closed
2010Aug03 15:03:44.096 52-2 Close 52-CS:VI3 : High
2010Aug03 15:03:42.798 Spare 1:OUT1 : Open
2010Aug03 15:03:42.696 52-1 Close 52-CS:VI1 : Low
2010Aug03 15:03:41.885 52-1 "a" status:PL2 : High
2010Aug03 15:03:41.685 Spare 1:OUT1 : Closed
2010Aug03 15:03:41.663 52-1 Close 52-CS:VI1 : High
Erase
Refresh
Print
Close
Main Menu
Config Mgr
Metering
Utilities
Events
Relay 4000 Control Panel
Current IED: L43
Getting Events

Figure L.34: 79-3Ph Initiated: High

12 Go to the Control Virtual Inputs and select “52-1, 52-2 Trip&79I” using the Pulse On action for the Virtual Input 5. This will trip both breakers and initiate the reclosing sequence.

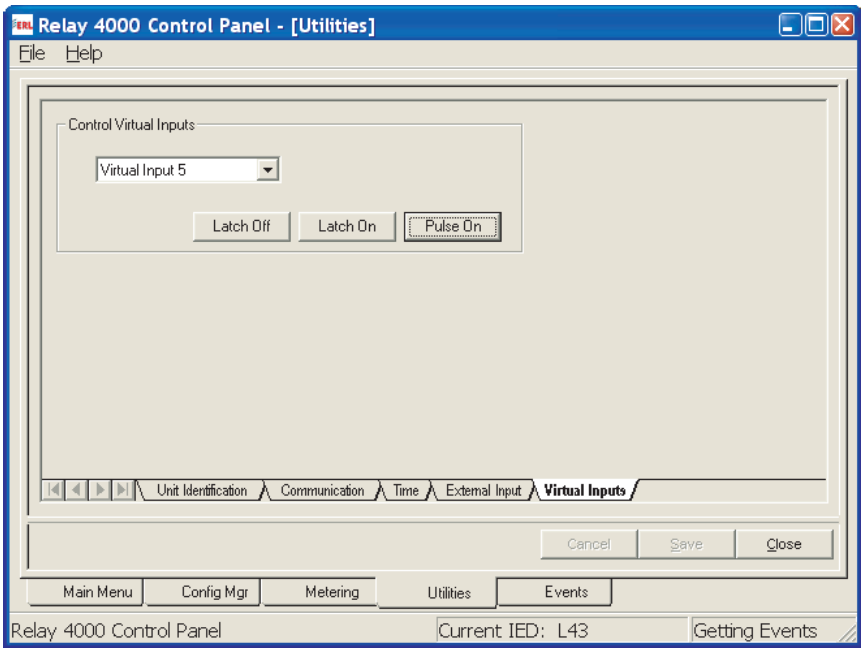


Figure L.35: select 52-1, 52-2 Trip&79I using the Pulse On action

13 Check the event log and confirm that 52-1was the first breaker and 52-2 was the second breaker. Check open interval time and follower time, the close pulse can be measured from the time between PL9 and PL10 going high.

- T1 - Open interval time equals time from 79 Initiate event to 79 Main Reclose (shot 1) event.
- TP - Close pulse time equals time from TP start: PL9 event to TP end: PL10 event.
- TF - Follow breaker time equals time from 52-1 “a” status: PL2 event to 79 Au Auxiliary Reclose (shot 1) event.

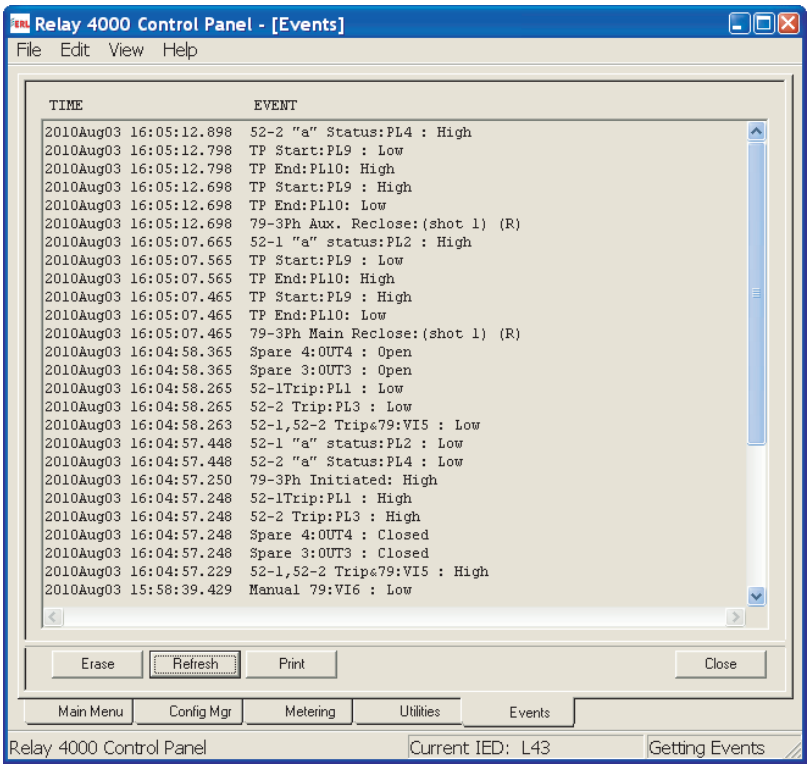

Relay 4000 Control Panel - [Events]
File Edit View Help
TIME EVENT
2010Aug03 16:05:12.898 52-2 "a" Status:PL4 : High
2010Aug03 16:05:12.798 TP Start:PL9 : Low
2010Aug03 16:05:12.798 TP End:PL10: High
2010Aug03 16:05:12.698 TP Start:PL9 : High
2010Aug03 16:05:12.698 TP End:PL10: Low
2010Aug03 16:05:12.698 79-3Ph Aux. Reclose:(shot 1) (R)
2010Aug03 16:05:07.665 52-1 "a" status:PL2 : High
2010Aug03 16:05:07.565 TP Start:PL9 : Low
2010Aug03 16:05:07.565 TP End:PL10: High
2010Aug03 16:05:07.465 TP Start:PL9 : High
2010Aug03 16:05:07.465 TP End:PL10: Low
2010Aug03 16:05:07.465 79-3Ph Main Reclose:(shot 1) (R)
2010Aug03 16:04:58.365 Spare 4:OUT4 : Open
2010Aug03 16:04:58.365 Spare 3:OUT3 : Open
2010Aug03 16:04:58.265 52-1Trip:PL1 : Low
2010Aug03 16:04:58.265 52-2 Trip:PL3 : Low
2010Aug03 16:04:58.263 52-1,52-2 Trip&79:VI5 : Low
2010Aug03 16:04:57.448 52-1 "a" status:PL2 : Low
2010Aug03 16:04:57.448 52-2 "a" Status:PL4 : Low
2010Aug03 16:04:57.250 79-3Ph Initiated: High
2010Aug03 16:04:57.248 52-1Trip:PL1 : High
2010Aug03 16:04:57.248 52-2 Trip:PL3 : High
2010Aug03 16:04:57.248 Spare 4:OUT4 : Closed
2010Aug03 16:04:57.248 Spare 3:OUT3 : Closed
2010Aug03 16:04:57.229 52-1,52-2 Trip&79:VI5 : High
2010Aug03 15:58:39.429 Manual 79:VI6 : Low
Erase
Refresh
Print
Close
Main Menu
Config Mgr
Metering
Utilities
Events
Relay 4000 Control Panel
Current IED: L43
Getting Events

Figure L.36: Main and Aux Recloser operating sequence events

14 Go to the Control Virtual Inputs and select “52-1 Trip 52-CS” using the Pulse On action for the virtual inputs. This will trip breaker 52-1 and after timer TC, 52-2 (follow breaker) will move into the lead position.

15 Go to the Control Virtual Inputs and select “52-1, 52-2 Trip&79I” using the Pulse On action for the virtual inputs. This will trip breaker 52-2 and initiate the reclosing sequence.

16 Check the event log and confirm that only 52-2 breaker reclosed and was in the lead position. Confirm that 52-1 breaker did not receive any reclose attempts.

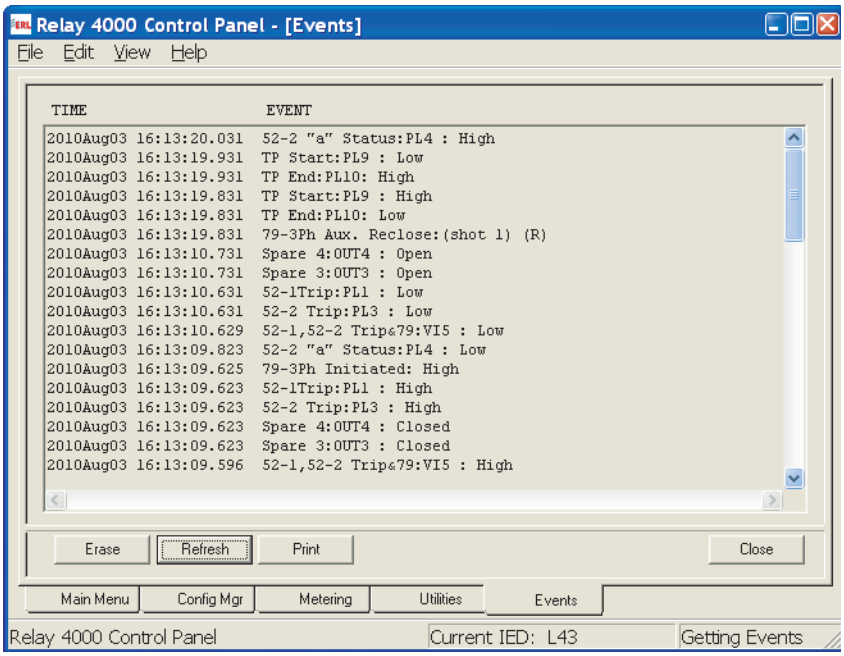

Relay 4000 Control Panel - [Events]
File Edit View Help
TIME EVENT
2010Aug03 16:13:20.031 52-2 "a" Status:PL4 : High
2010Aug03 16:13:19.931 TP Start:PL9 : Low
2010Aug03 16:13:19.931 TP End:PL10: High
2010Aug03 16:13:19.831 TP Start:PL9 : High
2010Aug03 16:13:19.831 TP End:PL10: Low
2010Aug03 16:13:19.831 79-3Ph Aux. Reclose:(shot 1) (R)
2010Aug03 16:13:10.731 Spare 4:OUT4 : Open
2010Aug03 16:13:10.731 Spare 3:OUT3 : Open
2010Aug03 16:13:10.631 52-1Trip:PL1 : Low
2010Aug03 16:13:10.631 52-2 Trip:PL3 : Low
2010Aug03 16:13:10.629 52-1,52-2 Trip&79:VI5 : Low
2010Aug03 16:13:09.823 52-2 "a" Status:PL4 : Low
2010Aug03 16:13:09.625 79-3Ph Initiated: High
2010Aug03 16:13:09.623 52-1Trip:PL1 : High
2010Aug03 16:13:09.623 52-2 Trip:PL3 : High
2010Aug03 16:13:09.623 Spare 4:OUT4 : Closed
2010Aug03 16:13:09.623 Spare 3:OUT3 : Closed
2010Aug03 16:13:09.596 52-1,52-2 Trip&79:VI5 : High
Erase
Refresh
Print
Close
Main Menu
Config Mgr
Metering
Utilities
Events
Relay 4000 Control Panel
Current IED: L43
Getting Events

Figure L.37: Only 52-2 breaker reclosed and was in the lead position

17 Go to the Control Virtual Inputs and select “52-1 Close 52-CS” using the Pulse On action for the virtual inputs. This will close breaker 52-1 and after a fixed delay of 10.0 seconds breaker 52-1 will move back into the lead position and 52-2 (follow breaker) will move back into the follow position.

18 Go to the Control Virtual Inputs and select “52-1, 52-2 Trip&79I” using the Pulse On action for the virtual inputs. This will trip both breakers and initiate the reclosing sequence.

19 After 52-1 closes and before 52-2 closes select “52-1, 52-2 Trip&79I” using the Pulse On action for the virtual inputs. This will trip breaker 52-1 and cause a lockout alarm to be generated and block the follow breaker reclose attempt.

20 Check the event log and confirm the 79 Lead Lockout event and that there was no follow breaker reclose attempt.

- 79 Lead Lockout - The time equals time from 79 Initiate event to 79 Lead Lockout event (approx. TP + 1.0s).

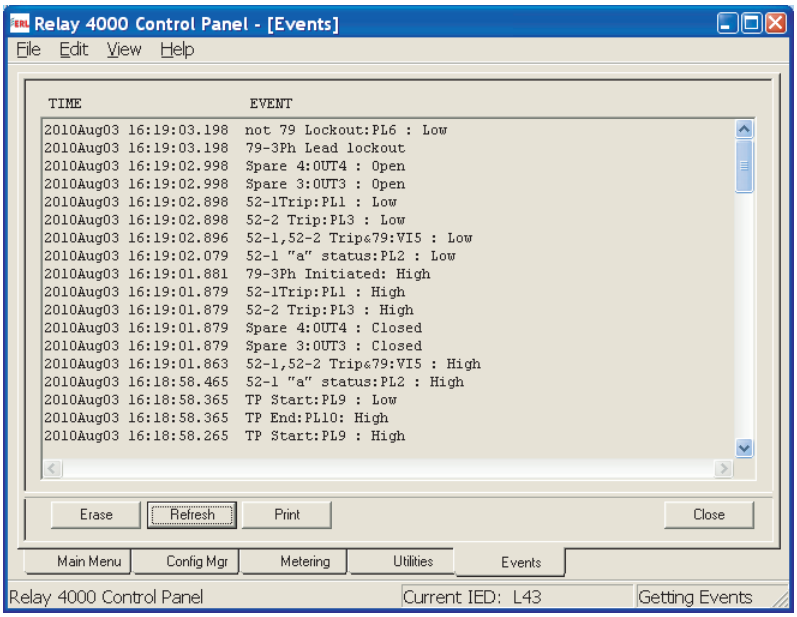

Relay 4000 Control Panel - [Events]
File Edit View Help
TIME EVENT
2010Aug03 16:19:03.198 not 79 Lockout:PL6 : Low
2010Aug03 16:19:03.198 79-3Ph Lead lockout
2010Aug03 16:19:02.998 Spare 4:OUT4 : Open
2010Aug03 16:19:02.998 Spare 3:OUT3 : Open
2010Aug03 16:19:02.898 52-1Trip:PL1 : Low
2010Aug03 16:19:02.898 52-2 Trip:PL3 : Low
2010Aug03 16:19:02.896 52-1,52-2 Trip&79:VI5 : Low
2010Aug03 16:19:02.079 52-1 "a" status:PL2 : Low
2010Aug03 16:19:01.881 79-3Ph Initiated: High
2010Aug03 16:19:01.879 52-1Trip:PL1 : High
2010Aug03 16:19:01.879 52-2 Trip:PL3 : High
2010Aug03 16:19:01.879 Spare 4:OUT4 : Closed
2010Aug03 16:19:01.879 Spare 3:OUT3 : Closed
2010Aug03 16:19:01.863 52-1,52-2 Trip&79:VI5 : High
2010Aug03 16:18:58.465 52-1 "a" status:PL2 : High
2010Aug03 16:18:58.365 TP Start:PL9 : Low
2010Aug03 16:18:58.365 TP End:PL10: High
2010Aug03 16:18:58.265 TP Start:PL9 : High
Erase
Refresh
Print
Close
Main Menu
Config Mgr
Metering
Utilities
Events
Relay 4000 Control Panel
Current IED: L43
Getting Events

Figure L.38: 79-3Ph Lead lockout event log

21 Go to the Control Virtual Inputs and select “52-1 Close 52-CS” using the Pulse On action for the virtual inputs. This will close breaker 52-1 and after a fixed delay of TD seconds the recloser will reset.

Communication -aided Tripping Schemes

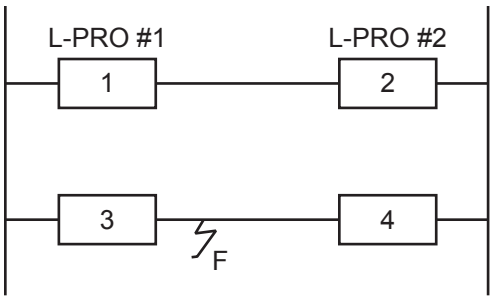


Figure L.39: Current Reversal Logic example

Current Reversal Logic Example

The relays are installed and provide line protection by the tripping Breaker #1 and Breaker #2 respectively. A ground fault occurs at location F in the parallel line. Initially, 21N2 of L-PRO #2 picks up and sends a permissive transfer trip signal to L-PRO #1. Since L-PRO #1 detects a reverse fault (21N4 picks up), it neither trips the breaker nor sends a permissive transfer trip signal. When breaker #3 opens due to a zone 1 trip, the current reversal condition occurs on L-PRO #1. If the 21P2 on L-PRO #1 operates, and if the received permissive transfer trip signal from L-PRO #2 still exists the POTT scheme on L-PRO #1 will trip breaker #1. To prevent this unwanted tripping on the parallel line, the relay has current reversal logic. The relay current reversal logic prevents the false trip during this current reversal condition. Gate #116 of the functional logic diagram and timer TL1 and TD1 stretch the zone 4 logic and block the POTT scheme from tripping the breaker or sending the transfer trip signal to the remote end.

Communication -aided Tripping Scheme Timer Considerations

The basic selection does not provide any communication-aided logic for local or remote protections.

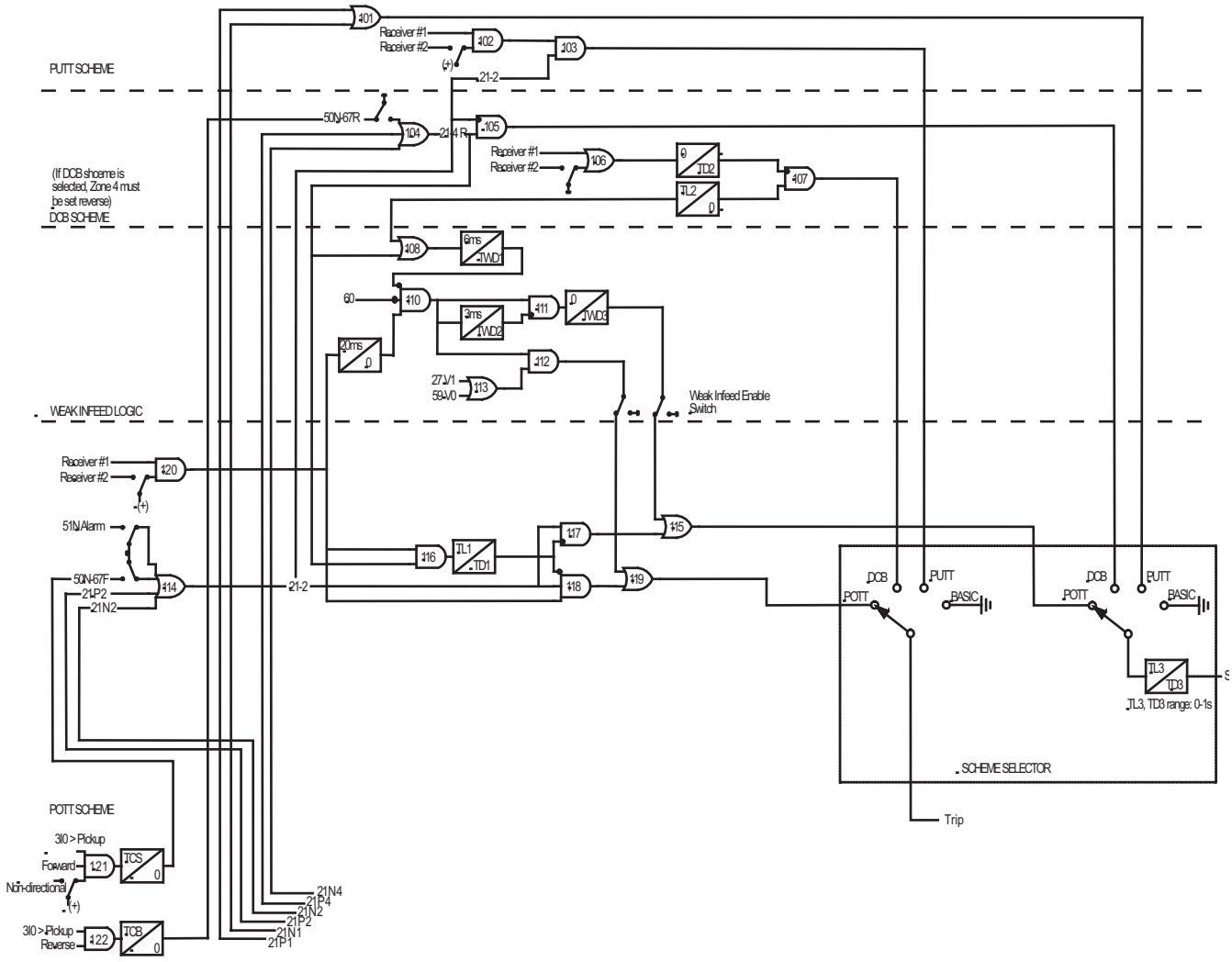


Figure L.40: Communication-aided Scheme

L-PRO Scheme Timers Summary

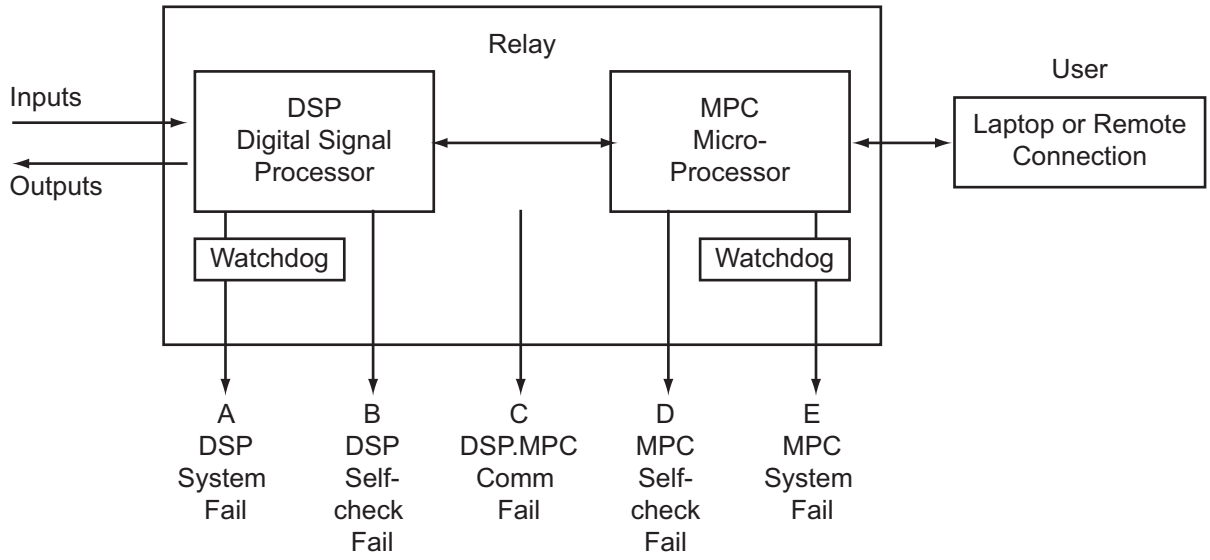
Table 1.3: DCB Scheme Timers	
Timer	**Considerations**
TD2	Upon receipt of a Blocking Signal at the local end from the remote end, TD2 extends the Blocking Signal to prevent a Scheme Trip. The Blocking Signal should be extended by: Time for the local 21-2 to de-assert (~1 cycle) – Blocking Signal Channel Reset Time (i.e. the time for the removal of the Block to propagate from the remote end to the local end) + Security Margin*.
TL2	Delays the local 21-2 from producing a Scheme Trip for at least as long as it would take a Blocking Signal to arrive from the remote end. Should be set longer than the remote end 21-4R (OR 50-67R) detection time (~1 cycle) + Blocking Channel Time + Security Margin*.

Table 1.4: POTT Scheme Timers	
Timer	**Considerations**
TL1	TL1 is intended for Parallel Line applications**: Delays or prevents scheme trip upon detection of a current reversal at the local end. Time Delay should be set to less than: Remote End 21-2 Detection Time (~25msec) + Total End to End Channel Time
TD1	Also for Parallel Line Applications**: Extends current reversal blocking of the Scheme Trip and Send. Should be set such that it will not block the local relay if the fault becomes forward and internal. However it needs to be set long enough to allow the permissive trip from the remote end to de-assert in the event that the remote fault reverses (remote external reverse fault). So, set local TD2 to: Remote 21-2 Reset Time + Channel Reset Time + Security Margin*.

Table 1.5: Scheme Selector Timers	
Timer	**Considerations**
TL3	Local fault duration must be greater than this time in order to produce a Scheme Send. POTT and PUTT = Permissive Trip DCB = Block Signal (derived from 21-4R (OR 50N-67R) AND NOT 21-2)
TD3	Stretches the Scheme Send signal to ensure that it's received by the remote end relay. Set longer than the channel pickup delay.

Notes:
* Security Margin = 0.5 to 1 cycle or a percentage of total expected time to account for errors in scheme timing assumptions.
** Parallel Line applications: fault contribution can come from unfaulted line appearing as a Zone 2 fault at one end and zone 4 reverse fault at the other end. Depending on the location of the fault on the faulted line and which breaker clears first, the current may change direction and the 2 terminals on the unfaulted line may change state from forward to reverse and reverse to forward. The unfaulted line contribution may come either end on a networked system.

Appendix M Failure Modes



M.1 Actions

A - DSP System Failure

The Relay Functional LED changes from green to off. The Master Relay is de-energized. Two of its contacts open, disconnecting power to the other auxiliary relays. A separate contact labeled “Relay Inoperative” on the rear panel closes to activate a remote alarm.

The watch-dog repeatedly attempts to re-start the DSP for diagnostic purposes. The Relay Functional LED stays off and the relays remain de-energized, even for a successful re-start. Only a power-down/power-up cycle will reset the LED to green and re-energize the relays.

B – DSP Self-Check Fail

The Self Check Fail output can be assigned and used in ProLogic statements and the Output Matrix.

There are two possibilities for DSP Self Check Fail, either Alarm or Block. Both are related to the dc offset on a channel which should not occur with proper calibration. Alarm just drives the optional output contact but Block causes the Relay Functional LED to go out and the relay to be unable to drive any output contact (as in the first and last paragraphs of section A - DSP System Failure above).

C – DSP- Micro Processor (MPC) Comm Failure

D - MPC Self-Check Fail

The Service Required LED changes from off to red.

E – MPC System Fail

The Test Mode LED changes from off to red until the MPC has rebooted. The watchdog will continue to attempt to re-start the MPC several times. If the MPC reboots but can not return to normal operation, the Service Required LED changes from off to red.

Appendix N IEC61850 Implementation

N.1 Protocol Implementation Conformance Statement (PICS)

Introduction

This specification is the Protocol Implementation Conformance Statement (PICS) and presents the ACSI conformance statements as defined in Annex A of Part 7-2 of the IEC 61850 standard specifications.

ACSI basic conformance statement

The basic conformance statement shall be as defined in Table N.1: Basic Conformance Statement.

Table N.1: Basic Conformance Statement

		Server/Publisher	Remarks
Client -Server Roles			
B11	**Server** Side (of two-party-application-association)	c1	YES
B12	**Client** Side (of two-party-application-association)		NO
SCSMs supported			
B21	**SCSM**:IEC 61850-8-1 used		YES
B22	**SCSM**:IEC 61850-9-1 used		NO
B23	**SCSM**:IEC 61850-9-2 used		NO
B24	**SCSM**: other		NO
Generic Substation event Model(GSE)			
B31	**Publisher** side	O	YES
B32	**Subscriber** Side		YES
Transmission of Sampled value model (SVC)			
B41	**Publisher** side	O	NO
B42	**Subscriber** side	-	NO

c1 - Shall be 'M' if support for **Logical-device** model has been declared
O - Optional
M - Mandatory

ACSI models conformance statement

The ASCI models conformance statement shall be as defined in Table N.2: ACSI models Conformance Statement.

Table N.2: ACSI models Conformance Statement			
		Server/ Publisher	**Remarks**
If Sever side (B11) supported			
M1	Logical Device	c2	YES
M2	Logical Node	c3	YES
M3	Data	c4	YES
M4	Data Set	c5	YES
M5	Substitution	O	YES
M6	Setting group control	O	NO
Reporting			
M7	Buffered report control	O	YES
M7-1	Sequence – number		YES
M7-2	Report-time-stamp		YES
M7-3	Reason-for-inclusion		YES
M7-4	Data-set-name		YES
M7-5	Data-reference		YES
M7-6	Buffer-overflow		YES
M7-7	Entry id		YES
M7-8	Buf Tm		YES
M7-9	IntgPd		YES
M7-10	GI		YES
M8	Unbuffered report control	O	YES
M8-1	Sequence – number		YES
M8-2	Report-time-stamp		YES
M8-3	Reason-for-inclusion		YES
M8-4	Data-set-name		YES
M8-5	Data-reference		YES
M8-6	IntgPd		YES
M8-7	GI		YES
	Logging	O	NO

Table N.2: ACSI models Conformance Statement			
M9	Log control	O	NO
M9-1	IntgPd		NO
M10	Log	O	NO
M11	Control	M	NO
If GSE (B31/B32) is supported			
	M12-1	EntryID	
	M12-2	DataReflnc	

ACSI service conformance statement

The ASCI service conformance statement shall be as defined in Table N.3: ACSI service Conformance Statement.

Table N.3: ACSI service Conformance Statement				
	Services	AA: TP/MC	Server/ Publisher	Remarks
Server (Clause 6)				
S1	ServerDirectory	TP	M	YES

Table N.4: Application association (Clause 7)				
S2	Associate		M	YES
S3	Abort		M	YES
S4	Release		M	YES

Table N.5: Logical device (Clause 8)				
S5	Logical Device Directory	TP	M	YES

Table N.6: Logical Node (Clause 9)				
S6	LogicalNodeDirectory	TP	M	YES
S7	GetAllDataValues	TP	M	YES

Table N.7: Data (Clause 10)				
S8	GetDataValues	TP	M	YES
S9	SetDataValues	TP	O	YES
S10	GetDataDirectory	TP	M	YES
S11	GetDataDefinition	TP	M	YES

Table N.8: Data Set(Clause 11				
S12	GetDataSetValues	TP	M	YES
S13	SetDataSetValues	TP	O	NO
S14	CreateDataSet	TP	O	NO
S15	DeleteDataSet	TP	O	NO
S16	GetDataSetDirectory	TP	O	YES

Table N.9: Substitution (Clause 12)				
S17	SetDataValues	TP	M	YES

Table N.10: Setting group control (Clause 13)				
S18	SelectActive SG	TP	O	NO
S19	SelectEdit SG	TP	O	NO
S20	SetSGvalues	TP	O	NO
S21	ConfirmEditSGvalues	TP	O	NO
S22	GetSGvalues	TP	O	NO
S23	GetSGCBvalues	TP	O	NO

Table N.11: Reporting (Clause 14)				
Buffered report control block(BRCB)				
S24	Report	TP	c6	YES
S24-1	Data-change(dchg)			YES
S24-2	qchg-change(qchg)			NO
S24-3	Data-update(dupd)			NO
S25	GetBRCBValues	TP	c6	YES
S26	SetBRCBValues	TP	c6	YES
Unbuffered report control block(URCB)				
S27	Report	TP	c6	YES
S27-1	Data-change(dchg)			YES
S27-2	qchg-change(qchg)			NO
S27-3	Data-update(dupd)			NO
S28	GetURCBValues	TP	c6	YES
S29	SetURCBValues	TP	c6	YES
c6 – shall declare support for at least one(BRCB or URCB)				

Table N.12: Logging(clause 14)				
Log Control block				
S30	GetLCBValues	TP	M	NO
S31	SetLCBValues	TP	M	NO
Log				
S32	QueryLogByTime	TP	M	NO
S33	QueryLogAfter	TP	M	NO
S34	GetLogStatusValues	TP	M	NO
c7- shall declare support for at least one(query log by time or Query LogAfter)				

Table N.13: Generic Substation event model(GSE) (14.3.5.3.4)				
GOOSE – CONTROL - BLOCK				
S35	SendGOOSEMessage	MC	c8	YES
S36	GetGOReference	TP	c9	
S37	GetGOOSEElementNumber	TP	c9	
S38	GetGoCBValues	TP	O	YES
S39	SetGoCBValues	TP	O	YES
GSSE – CONTROL - BLOCK				
S40	SendGSSEMessage	MC	C8	NO
S41	GetGsReference	TP	C9	NO
S42	GetGSSEElementNumber	TP	C9	NO
S43	GetGsCBValues	TP	O	NO
S44	SetGsCBValues	TP	O	NO
c8- shall declare support for at least one(Send GOOSE Message or Send GSSE Message) c9- shall declare support if TP association is available				

Table N.14: Transmission of sampled value model(SVC) (Clause 16)				
Multicast SVC				
S45	SendMSVMessage	MC	C10	NO
S46	GetMSVCBValues	TP	O	NO
S47	SetMSVCBValues	TP	O	NO
Unicast SVC				
S48	SendUSVMessage	TP	C10	NO
S49	GetUSVCBValues	TP	O	NO
S50	SetUSVCBValues	TP	O	NO
C10- shall declare support for at least one(Send MSV Message or Send USV Message)				

Table N.15: control (17.5.1)				
S51	Select	TP	O	NO
S52	Select with value	TP	O	NO
S53	Cancel	TP	O	NO
S54	Operate	TP	M	NO
S55	Command-Termination	TP	O	NO
S56	Time Activated-Operate	TP	O	NO

v

Table N.16: File Transfer (Clause 20)				
S57	GetFile	TP	M	YES
S58	SetFile	TP	O	YES
S59	DeleteFile	TP	O	YES
S60	GetFileAttributeValues	TP	M	YES

Table N.17: Time(5.5)			
T1	Time resolution of Internal clock	10 (1 msec)	Nearest negative power of 2 in seconds
T2	TimeAccuracy of Internal clock	10 (1 msec)	T0
			T1
			T2
			T3
			T4
			T5
T3	Supported Time Stamp resolution	10 (1 msec)	Nearest value of 2**-n in seconds according to 5.5.3.7.3.3

N.2 Model Implementation Conformance Statement (MICS)

Introduction

This specification is the Model Implementation Conformance Statement (MICS) and presents the top-level IEC 61850 data model that has been implemented. The definitions of all used Logical Nodes and their associated Common Data Classes, components and associated enumerated values are also included for completeness.

The reader is expected to be conversant with the terminology presented within the IEC 61850 part 7 series of specifications.

Objective

To provide comprehensive details of the standard data object model elements supported by the device. The MICS is conformant to the devices associated ICD (IED Capability Description) file, according to part 6 of the IEC 61850 standards. The layout of the presented tables within this document is conformant to the part 7 series of the IEC 61850 standard specifications with the following exceptions:

- The "Trigger Options" field is not presented
- The "M/O" field is not present as the definitions are as deployed within the model
- An additional column "X" is used to signify custom attributes

Logical Device Definitions

This IEC 61850 server device contains several Logical Devices. Each Logical Device (LD) contains a data model built from instances of specific Logical Nodes (LN) and must consist of at least an instance of the LPHD Logical Node (which is responsible for providing physical device information) and an instance of the LLN0 Logical Node (for addressing common issues across the Logical Device).

The IEC 61850 data model is contained within the Logical Devices detailed in the table below. All LNs are categorized according to the following table to ensure that data model variables in them have respective scope of data information.

Table N.18: Logical Devices

Logical Device	Comment / Usage
Protection	Protection Domain
FaultData	Fault Data Domain
Measurements	Measurements Domain

Table N.18: Logical Devices	
System	System Domain
Records	Records Domain
VirtualInputs	Virtual Inputs Domain

IEC 61850 Logical Devices Data Model

The IEC 61850 Logical Devices top-level data model consists of instances of Logical Nodes. The data model name for a Logical Node instance is constructed from an optional prefix (known as the wrapper), the Logical Node name, and an instance ID (or suffix).

LD	LN Instance	LN Type	Description
LD	LN Instance	LN Type	Description
Protection	D21P1PDIS1	PDIS1	Distance
Protection	D21P2PDIS2	PDIS1	Distance
Protection	D21P3PDIS3	PDIS1	Distance
Protection	D21P4PDIS4	PDIS1	Distance
Protection	D21P5PDIS5	PDIS1	Distance
Protection	LodEncPDIS6	PDIS3	Distance
Protection	D21N1PDIS7	PDIS2	Distance
Protection	D21N2PDIS8	PDIS2	Distance
Protection	D21N3PDIS9	PDIS2	Distance
Protection	D21N4PDIS10	PDIS2	Distance
Protection	D21N5PDIS11	PDIS2	Distance
Protection	D2527RSYN1	RSYN1	Synchronism-check
Protection	D27MnPTUV1	PTUV1	Undervoltage
Protection	D27AuxPTUV2	PTUV1	Undervoltage
Protection	D50BF1RBRF1	RBRF1	Breaker failure
Protection	D50BF2RBRF2	RBRF1	Breaker failure
Protection	D50BF3RBRF3	RBRF1	Breaker failure
Protection	D50BF4RBRF4	RBRF1	Breaker failure
Protection	CBFIRBRF5	RBRF1	Breaker failure
Protection	D50LS1PIOC1	PIOC1	Instantaneous overcurrent
Protection	D50LS2PIOC2	PIOC1	Instantaneous overcurrent

Protection	D50PIOC3	PIOC2	Instantaneous overcurrent
Protection	D50NPIOC4	PIOC3	Instantaneous overcurrent
Protection	D46_50PIOC5	PIOC3	Instantaneous overcurrent
Protection	D51PTOC1	PTOC1	Time overcurrent
Protection	D51NPTOC2	PTOC2	Time overcurrent
Protection	D46_51NPTOC3	PTOC2	Time overcurrent
Protection	D59MPTOV1	PTOV1	Overvoltage
Protection	D59APTOV2	PTOV1	Overvoltage
Protection	D59M2PTOV3	PTOV1	Overvoltage
Protection	D59A2PTOV4	PTOV1	Overvoltage
Protection	D59NPTOV5	PTOV2	Overvoltage
Protection	DTLPTOV6	PTOV2	Overvoltage
Protection	D68TrRPSB1	RPSB1	Power swing detection/blocking
Protection	D68B1RPSB2	RPSB2	Power swing detection/blocking
Protection	D68B2RPSB3	RPSB2	Power swing detection/blocking
Protection	D68B3RPSB4	RPSB2	Power swing detection/blocking
Protection	D68B4RPSB5	RPSB2	Power swing detection/blocking
Protection	D68B5RPSB6	RPSB2	Power swing detection/blocking
Protection	D79MRREC1	RREC1	Autoreclosing
Protection	D79ARREC2	RREC1	Autoreclosing
Protection	D81_1PTOF1	PTOF1	Overfrequency
Protection	D81_2PTOF2	PTOF1	Overfrequency
Protection	D81_3PTOF3	PTOF1	Overfrequency
Protection	D81_4PTOF4	PTOF1	Overfrequency
Protection	D81_1PTUF1	PTUF1	Underfrequency
Protection	D81_2PTUF2	PTUF1	Underfrequency
Protection	D81_3PTUF3	PTUF1	Underfrequency
Protection	D81_4PTUF4	PTUF1	Underfrequency
Protection	D81_1PFRC1	PFRC1	Rate of change of frequency
Protection	D81_2PFRC2	PFRC1	Rate of change of frequency
Protection	D81_3PFRC3	PFRC1	Rate of change of frequency
Protection	D81_4PFRC4	PFRC1	Rate of change of frequency
Protection	DisSchPSCH1	PSCH1	Protection scheme
Protection	DEFSchPSCH2	PSCH2	Protection scheme
Protection	PTFuseGGIO6	GGIO6	Generic process I/O
Protection	CTSGGIO7	GGIO7	Generic process I/O

Protection	SOTFGGIO8	GGIO8	Generic process I/O
FaultData	D21P1RFLO1	RFLO1	Fault locator
FaultData	D21P2RFLO2	RFLO1	Fault locator
FaultData	D21P3RFLO3	RFLO1	Fault locator
FaultData	D21P4RFLO4	RFLO1	Fault locator
FaultData	D21P5RFLO5	RFLO1	Fault locator
FaultData	D21N1RFLO6	RFLO1	Fault locator
FaultData	D21N2RFLO7	RFLO1	Fault locator
FaultData	D21N3RFLO8	RFLO1	Fault locator
FaultData	D21N4RFLO9	RFLO1	Fault locator
FaultData	D21N5RFLO10	RFLO1	Fault locator
FaultData	DSCHRFLO11	RFLO1	Fault locator
FaultData	D21P1MMXU1	MMXU2	Measurement
FaultData	D21P2MMXU2	MMXU2	Measurement
FaultData	D21P3MMXU3	MMXU2	Measurement
FaultData	D21P4MMXU4	MMXU2	Measurement
FaultData	D21P5MMXU5	MMXU2	Measurement
FaultData	D21N1MMXU6	MMXU2	Measurement
FaultData	D21N2MMXU7	MMXU2	Measurement
FaultData	D50LSMMMXU8	MMXU4	Measurement
FaultData	D50LSAMMXU9	MMXU4	Measurement
FaultData	D21N5MMXU10	MMXU2	Measurement
FaultData	DSCHMMXU11	MMXU2	Measurement
FaultData	D59MMMXU12	MMXU3	Measurement
FaultData	D59AMMXU13	MMXU3	Measurement
FaultData	D27MMMXU14	MMXU3	Measurement
FaultData	D27AMMXU15	MMXU3	Measurement
FaultData	D21N3MMXU16	MMXU2	Measurement
FaultData	D21N4MMXU17	MMXU2	Measurement
FaultData	D5067MMXU18	MMXU4	Measurement
FaultData	D5167MMXU19	MMXU4	Measurement
FaultData	D59M2MMXU20	MMXU3	Measurement
FaultData	D59A2MMXU21	MMXU3	Measurement
FaultData	D21N1MSQI1	MSQI1	Sequence and imbalance
FaultData	D21N2MSQI2	MSQI1	Sequence and imbalance

FaultData	D21N3MSQI3	MSQI1	Sequence and imbalance
FaultData	D21N4MSQI4	MSQI1	Sequence and imbalance
FaultData	D21N5MSQI5	MSQI1	Sequence and imbalance
FaultData	DSCHMSQI6	MSQI1	Sequence and imbalance
FaultData	D4650MSQI7	MSQI2	Sequence and imbalance
FaultData	D50N67MSQI8	MSQI2	Sequence and imbalance
FaultData	D51N67MSQI9	MSQI2	Sequence and imbalance
FaultData	D4651MSQI10	MSQI2	Sequence and imbalance
Measurements	MAINMMXU1	MMXU1	Measurement
Measurements	AUXMMXU2	MMXU5	Measurement
Measurements	MAINMSQI1	MSQI3	Sequence and imbalance
System	PLGGIO1	GGIO1	Generic process I/O
System	SGGGIO2	GGIO2	Generic process I/O
System	EIGGIO3	GGIO3	Generic process I/O
System	OCGGIO4	GGIO4	Generic process I/O
System	SChAlmGGIO5	GGIO10	Generic process I/O
System	LEDGGIO10	GGIO9	Generic process I/O
System	TSAlmGGIO12	GGIO10	Generic process I/O
System	VIGGIO13	GGIO5	Generic process I/O
Recorder	RDRE1	RDRE1	Disturbance recorder function
VirtualInputs	SUBSCRGGIO1	GGIO11	Generic process I/O

Logical Node Definitions

The definition tables for each of the Logical Nodes in the top-level data model are presented in the following sub-sections.

The following table presents a summary of the Logical Node templates used across the

Logical Devices within the overall IEC 61850-product data model:

LN Type	LN Class	Name Space
LPHD1	LPHD	IEC61850–7–4: 2003
LPHD2	LPHD	IEC61850–7–4: 2003
LLN0	LLN0	IEC61850–7–4: 2003
LLN01	LLN01	IEC61850–7–4: 2003
PDIS1	PDIS	IEC61850–7–4: 2003
PDIS2	PDIS	IEC61850–7–4: 2003
PDIS3	PDIS	IEC61850–7–4: 2003
RSYN1	RSYN	IEC61850–7–4: 2003
RREC1	RREC	IEC61850–7–4: 2003
PTOV1	PTOV	IEC61850–7–4: 2003
PTOV2	PTOV	IEC61850–7–4: 2003
PTUV1	PTUV	IEC61850–7–4: 2003
PTOF1	PTOF	IEC61850–7–4: 2003
PTUF1	PTUF	IEC61850–7–4: 2003
PFRC1	PFRC	IEC61850–7–4: 2003
PIOC1	PIOC	IEC61850–7–4: 2003
PIOC2	PIOC	IEC61850–7–4: 2003
PIOC3	PIOC	IEC61850–7–4: 2003
RBRF1	RBRF	IEC61850–7–4: 2003
PTOC1	PTOC	IEC61850–7–4: 2003
PTOC2	PTOC	IEC61850–7–4: 2003
RPSB1	RPSB	IEC61850–7–4: 2003
RPSB2	RPSB	IEC61850–7–4: 2003
PSCH1	PSCH	IEC61850–7–4: 2003
PSCH2	PSCH	IEC61850–7–4: 2003
RFLO1	RFLO	IEC61850–7–4: 2003
MMXU1	MMXU	IEC61850–7–4: 2003

MMXU2	MMXU	IEC61850–7–4: 2003
MMXU3	MMXU	IEC61850–7–4: 2003
MMXU4	MMXU	IEC61850–7–4: 2003
MMXU5	MMXU	IEC61850–7–4: 2003
MSQI1	MSQI	IEC61850–7–4: 2003
MSQI2	MSQI	IEC61850–7–4: 2003
MSQI3	MSQI	IEC61850–7–4: 2003
GGIO1	GGIO	IEC61850–7–4: 2003
GGIO2	GGIO	IEC61850–7–4: 2003
GGIO3	GGIO	IEC61850–7–4: 2003
GGIO4	GGIO	IEC61850–7–4: 2003
GGIO5	GGIO	IEC61850–7–4: 2003
GGIO6	GGIO	IEC61850–7–4: 2003
GGIO7	GGIO	IEC61850–7–4: 2003
GGIO8	GGIO	IEC61850–7–4: 2003
GGIO9	GGIO	IEC61850–7–4: 2003
GGIO10	GGIO	IEC61850–7–4: 2003
GGIO11	GGIO	IEC61850–7–4: 2003
RDRE1	RDRE	IEC61850–7–4: 2003

Logical Node: LPHD1

Description: Physical Device Information

LN Class: LPHD

Attribute	Attr. Type	Explanation	T	X
PhyNam	DPL_2_PhyNam	Device Physical Name Plate		
PhyHealth	INS_2_PhyHealth	Physical Device Health		
Proxy	SPS_1_Proxy	Indicates if this device is proxy		

Logical Node: LPHD2

Description: Physical Device Information

LN Class: LPHD

Attribute	Attr. Type	Explanation	T	X
PhyNam	DPL_2_PhyNam	Device Physical Name Plate		
PhyHealth	INS_2_PhyHealth	Physical Device Health		
Proxy	SPS_1_Proxy	Indicates if this device is proxy		

Logical Node: LLN0

Description: Logical Node 0

LN Class: LLN0

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_3_NamPlt	Name Plate		

Logical Node: LLN01

Description: Logical Node 0

LN Class: LLN0

Attribute	Attr. Type	Explanation	T	X
Mod	INC_3_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_3_NamPlt	Name Plate		

Logical Node: MMXU1

Description: Measurements

LN Class: MMXU

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
TotW	MV_1_TotW	Total Active Power (Total P)		
TotVAr	MV_1_TotW	Total Reactive Power (Total Q)		
TotVA	MV_1_TotW	Total Apparent Power (Total S)		
TotPF	MV_1_TotW	Average Power Factor (Total PF)		
Hz	MV_1_TotW	Frequency		
PhV	WYE_1_Z	Phase to Ground Voltage		
A	WYE_1_Z	Phase Currents		
W	WYE_1_W	Phase Active Power (W)		
VAr	WYE_1_W	Phase Reactive Power (Q)		
VA	WYE_1_W	Phase Apparent Power (S)		
PF	WYE_1_W	Phase power factor		
Z	WYE_1_Z	Phase to Ground Impedance (Z)		

Logical Node: PDIS1

Description: Distance

LN Class: PDIS

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_6_Op	Operate		

Logical Node: PDIS2

Description: Distance

LN Class: PDIS

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_5_Op	Operate		

Logical Node: PDIS3

Description: Distance

LN Class: PDIS

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_1_Op	Operate		

Logical Node: RSYN1

Description: Synchronism-check or synchronising

LN Class: RSYN

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Rel	SPS_1_Proxy	Release		

Logical Node: RREC1

Description: Autoreclosing

LN Class: RREC

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Auto	SPS_1_Proxy	Automatic Operation		
Op	ACT_1_Op	Operate		
AutoRecSt	INS_1_AutoRecSt	Auto Reclosing Status		

Logical Node: PTOV1

Description: Overvoltage

LN Class: PTOV

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_2_Str	Start		

Logical Node: PTOV2

Description: Overvoltage

LN Class: PTOV

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_1_Op	Operate		

Logical Node: PTUV1

Description:Undervoltage

LN Class: PTUV

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_2_Str	Start		
Op	ACT_1_Op	Operate		

Logical Node: PTOF1

Description: Overfrequency

LN Class: PTOF

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_1_Op	Operate		

Logical Node: PTUF1

Description: Underfrequency

LN Class: PTUF

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_1_Op	Operate		

Logical Node: PFRC1

Description: Rate of change of frequency

LN Class: PFRC

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_1_Op	Operate		

Logical Node: PIOC1

Description: Instantaneous overcurrent

LN Class: PIOC

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Op	ACT_5_Op	Operate		

Logical Node: PIOC2

Description: Instantaneous overcurrent

LN Class: PIOC

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_5_Op	Operate		

Logical Node: PIOC3

Description: Instantaneous overcurrent

LN Class: PIOC

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_1_Op	Operate		

Logical Node: RBRF1

Description: Breaker failure

LN Class: RBRF

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
OpEx	ACT_1_Op	Breaker Failure Trip (external trip)		

Logical Node: PTOC1

Description: Time overcurrent

LN Class: PTOC

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_5_Op	Operate		

Logical Node: PTOC2

Description: Time overcurrent

LN Class: PTOC

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
Op	ACT_1_Op	Operate		

Logical Node: RPSB1

Description: Power swing detection/blocking

LN Class: RPSB

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Op	ACT_1_Op	Operate		

Logical Node: RPSB2

Description: Power swing detection/blocking

LN Class: RPSB

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Str	ACD_5_Str	Start		
BlkZn	SPS_1_Proxy	Blocking of correlated PDIS zone		

Logical Node: PSCH1

Description: Protection scheme

LN Class: PSCH

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
ProTX	SPS_1_Proxy	Teleprotection signal transmitted		
ProRx	SPS_1_Proxy	Teleprotection signal transmitted		
Str	ACD_5_Str	Carrier Send		
Op	ACT_1_Op	Operate		
WeiOp	ACT_1_Op	Operate signal from weak end infeed function		

Logical Node: PSCH2

Description: Protection scheme

LN Class: PSCH

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
ProTX	SPS_1_Proxy	Teleprotection signal transmitted		
ProRx	SPS_1_Proxy	Teleprotection signal transmitted		
Str	ACD_5_Str	Carrier Send		
Op	ACT_1_Op	Operate		

Logical Node: RFLO1

Description: Fault locator

LN Class: RFLO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
FltZ	CMV_3_phsA	Fault Impedance		
FltDiskm	MV_1_TotW	Fault Distance in km		

Logical Node: MMXU2

Description: Measurements

LN Class: MMXU

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Hz	MV_1_TotW	Frequency		
PhV	WYE_1_Z	Phase to Ground Voltage		
A	WYE_1_Z	Phase Current		

Logical Node: MMXU3

Description: Measurements

LN Class: MMXU

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
PhV	WYE_1_Z	Phase to Ground Voltage		

Logical Node: MMXU4

Description: Measurements

LN Class: MMXU

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
A	WYE_1_Z	Phase Current		

Logical Node: MMXU5

Description: Measurements

LN Class: MMXU

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
PhV	WYE_1_Z	Phase to Ground Voltage		
A	WYE_1_Z	Phase Current		

Logical Node: MSQI1

Description: Sequence and imbalance

LN Class: MSQI

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
SeqA	SEQ_4_SeqA	Positive, Negative and Zero Sequence Current		
SeqV	SEQ_4_SeqA	Positive, Negative and Zero Sequence Current		

Logical Node: MSQI2

Description: Sequence and imbalance

LN Class: MSQI

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
SeqA	SEQ_4_SeqA	Positive, Negative and Zero Sequence Current		

Logical Node: MSQI3

Description: Sequence and imbalance

LN Class: MSQI

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
SeqA	SEQ_4_SeqA	Positive, Negative and Zero Sequence Current		
SeqV	SEQ_4_SeqA	Positive, Negative and Zero Sequence Current		

Logical Node: GGIO1

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind1	SPS_1_Proxy	General indication (binary input)		
Ind2	SPS_1_Proxy	General indication (binary input)		
Ind3	SPS_1_Proxy	General indication (binary input)		
Ind4	SPS_1_Proxy	General indication (binary input)		
Ind5	SPS_1_Proxy	General indication (binary input)		
Ind6	SPS_1_Proxy	General indication (binary input)		
Ind7	SPS_1_Proxy	General indication (binary input)		
Ind8	SPS_1_Proxy	General indication (binary input)		
Ind9	SPS_1_Proxy	General indication (binary input)		
Ind10	SPS_1_Proxy	General indication (binary input)		
Ind11	SPS_1_Proxy	General indication (binary input)		

Ind12	SPS_1_Proxy	General indication (binary input)		
Ind13	SPS_1_Proxy	General indication (binary input)		
Ind14	SPS_1_Proxy	General indication (binary input)		
Ind15	SPS_1_Proxy	General indication (binary input)		
Ind16	SPS_1_Proxy	General indication (binary input)		
Ind17	SPS_1_Proxy	General indication (binary input)		
Ind18	SPS_1_Proxy	General indication (binary input)		
Ind19	SPS_1_Proxy	General indication (binary input)		
Ind20	SPS_1_Proxy	General indication (binary input)		
Ind21	SPS_1_Proxy	General indication (binary input)		
Ind22	SPS_1_Proxy	General indication (binary input)		
Ind23	SPS_1_Proxy	General indication (binary input)		
Ind24	SPS_1_Proxy	General indication (binary input)		

Logical Node: GGIO2

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
IntIn	INS_1_IntIn	Integer status input		

Logical Node: GGIO3

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind1	SPS_1_Proxy	General indication (binary input)		
Ind2	SPS_1_Proxy	General indication (binary input)		
Ind3	SPS_1_Proxy	General indication (binary input)		
Ind4	SPS_1_Proxy	General indication (binary input)		
Ind5	SPS_1_Proxy	General indication (binary input)		
Ind6	SPS_1_Proxy	General indication (binary input)		
Ind7	SPS_1_Proxy	General indication (binary input)		
Ind8	SPS_1_Proxy	General indication (binary input)		
Ind9	SPS_1_Proxy	General indication (binary input)		
Ind10	SPS_1_Proxy	General indication (binary input)		
Ind11	SPS_1_Proxy	General indication (binary input)		
Ind12	SPS_1_Proxy	General indication (binary input)		
Ind13	SPS_1_Proxy	General indication (binary input)		
Ind14	SPS_1_Proxy	General indication (binary input)		
Ind15	SPS_1_Proxy	General indication (binary input)		
Ind16	SPS_1_Proxy	General indication (binary input)		
Ind17	SPS_1_Proxy	General indication (binary input)		
Ind18	SPS_1_Proxy	General indication (binary input)		
Ind19	SPS_1_Proxy	General indication (binary input)		
Ind20	SPS_1_Proxy	General indication (binary input)		

Logical Node: GGIO4

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind1	SPS_1_Proxy	General indication (binary input)		
Ind2	SPS_1_Proxy	General indication (binary input)		
Ind3	SPS_1_Proxy	General indication (binary input)		
Ind4	SPS_1_Proxy	General indication (binary input)		
Ind5	SPS_1_Proxy	General indication (binary input)		
Ind6	SPS_1_Proxy	General indication (binary input)		
Ind7	SPS_1_Proxy	General indication (binary input)		
Ind8	SPS_1_Proxy	General indication (binary input)		
Ind9	SPS_1_Proxy	General indication (binary input)		
Ind10	SPS_1_Proxy	General indication (binary input)		
Ind11	SPS_1_Proxy	General indication (binary input)		
Ind12	SPS_1_Proxy	General indication (binary input)		
Ind13	SPS_1_Proxy	General indication (binary input)		
Ind14	SPS_1_Proxy	General indication (binary input)		
Ind15	SPS_1_Proxy	General indication (binary input)		
Ind16	SPS_1_Proxy	General indication (binary input)		
Ind17	SPS_1_Proxy	General indication (binary input)		
Ind18	SPS_1_Proxy	General indication (binary input)		
Ind19	SPS_1_Proxy	General indication (binary input)		
Ind20	SPS_1_Proxy	General indication (binary input)		
Ind21	SPS_1_Proxy	General indication (binary input)		

Logical Node: GGIO5

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind1	SPS_1_Proxy	General indication (binary input)		
Ind2	SPS_1_Proxy	General indication (binary input)		
Ind3	SPS_1_Proxy	General indication (binary input)		
Ind4	SPS_1_Proxy	General indication (binary input)		
Ind5	SPS_1_Proxy	General indication (binary input)		
Ind6	SPS_1_Proxy	General indication (binary input)		
Ind7	SPS_1_Proxy	General indication (binary input)		
Ind8	SPS_1_Proxy	General indication (binary input)		
Ind9	SPS_1_Proxy	General indication (binary input)		
Ind10	SPS_1_Proxy	General indication (binary input)		
Ind11	SPS_1_Proxy	General indication (binary input)		
Ind12	SPS_1_Proxy	General indication (binary input)		
Ind13	SPS_1_Proxy	General indication (binary input)		
Ind14	SPS_1_Proxy	General indication (binary input)		
Ind15	SPS_1_Proxy	General indication (binary input)		
Ind16	SPS_1_Proxy	General indication (binary input)		
Ind17	SPS_1_Proxy	General indication (binary input)		
Ind18	SPS_1_Proxy	General indication (binary input)		
Ind19	SPS_1_Proxy	General indication (binary input)		
Ind20	SPS_1_Proxy	General indication (binary input)		
Ind21	SPS_1_Proxy	General indication (binary input)		
Ind22	SPS_1_Proxy	General indication (binary input)		
Ind23	SPS_1_Proxy	General indication (binary input)		
Ind24	SPS_1_Proxy	General indication (binary input)		
Ind25	SPS_1_Proxy	General indication (binary input)		
Ind26	SPS_1_Proxy	General indication (binary input)		

Ind27	SPS_1_Proxy	General indication (binary input)		
Ind28	SPS_1_Proxy	General indication (binary input)		
Ind29	SPS_1_Proxy	General indication (binary input)		
Ind30	SPS_1_Proxy	General indication (binary input)		

Logical Node: GGIO6

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind	SPS_1_Proxy	General indication (binary input)		

Logical Node: GGIO7

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind1	SPS_1_Proxy	General indication (binary input)		
Ind2	SPS_1_Proxy	General indication (binary input)		

Logical Node: GGIO8

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind	SPS_1_Proxy	General indication (binary input)		

ogical Node: GGIO9

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind1	SPS_1_Proxy	General indication (binary input)		
Ind2	SPS_1_Proxy	General indication (binary input)		
Ind3	SPS_1_Proxy	General indication (binary input)		
Ind4	SPS_1_Proxy	General indication (binary input)		
Ind5	SPS_1_Proxy	General indication (binary input)		
Ind6	SPS_1_Proxy	General indication (binary input)		
Ind7	SPS_1_Proxy	General indication (binary input)		
Ind8	SPS_1_Proxy	General indication (binary input)		
Ind9	SPS_1_Proxy	General indication (binary input)		
Ind10	SPS_1_Proxy	General indication (binary input)		
Ind11	SPS_1_Proxy	General indication (binary input)		
Ind12	SPS_1_Proxy	General indication (binary input)		
Ind13	SPS_1_Proxy	General indication (binary input)		

Logical Node: GGIO10

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind	SPS_1_Proxy	General indication (binary input)		

Logical Node: GGIO11

Description: Generic process I/O

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
Ind1	SPS_1_Proxy	General indication (binary input)		
Ind2	SPS_1_Proxy	General indication (binary input)		
Ind3	SPS_1_Proxy	General indication (binary input)		
Ind4	SPS_1_Proxy	General indication (binary input)		
Ind5	SPS_1_Proxy	General indication (binary input)		
Ind6	SPS_1_Proxy	General indication (binary input)		
Ind7	SPS_1_Proxy	General indication (binary input)		
Ind8	SPS_1_Proxy	General indication (binary input)		
Ind9	SPS_1_Proxy	General indication (binary input)		
Ind10	SPS_1_Proxy	General indication (binary input)		
Ind11	SPS_1_Proxy	General indication (binary input)		
Ind12	SPS_1_Proxy	General indication (binary input)		
Ind13	SPS_1_Proxy	General indication (binary input)		

Ind14	SPS_1_Proxy	General indication (binary input)		
Ind15	SPS_1_Proxy	General indication (binary input)		
Ind16	SPS_1_Proxy	General indication (binary input)		
Ind17	SPS_1_Proxy	General indication (binary input)		
Ind18	SPS_1_Proxy	General indication (binary input)		
Ind19	SPS_1_Proxy	General indication (binary input)		
Ind20	SPS_1_Proxy	General indication (binary input)		
Ind21	SPS_1_Proxy	General indication (binary input)		
Ind22	SPS_1_Proxy	General indication (binary input)		
Ind23	SPS_1_Proxy	General indication (binary input)		
Ind24	SPS_1_Proxy	General indication (binary input)		
Ind25	SPS_1_Proxy	General indication (binary input)		
Ind26	SPS_1_Proxy	General indication (binary input)		
Ind27	SPS_1_Proxy	General indication (binary input)		
Ind28	SPS_1_Proxy	General indication (binary input)		
Ind29	SPS_1_Proxy	General indication (binary input)		
Ind30	SPS_1_Proxy	General indication (binary input)		

Logical Node: RDRE1

Description: Disturbance recorder function

LN Class: RDRE

Attribute	**Attr. Type**	**Explanation**	**T**	**X**
Mod	INC_2_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_4_NamPlt	Name Plate		
RcdTrg	SPC_2_RcdTrg	Trigger recorder		
RcdMade	SPS_1_Proxy	Recording made		
FltNum	INS_1_IntIn	Fault Number		
RcdStr	SPS_1_Proxy	Recording started		

Common Data Class Definitions

The definition tables for each of the Common Data Classes used in the Logical Node definitions are presented in the following sub-sections.

From an application point-of-view the data attributes of a Common Data Class are classified according to their specific use. The characterization of data attributes, and the services that they support/provide, will be through the use of 'Functional Constraints'. The Functional Constraints are specified by the table below:

FC Name	Semantic	Source Definition
BR	Buffered Reports	IEC 61850 – 7 - 2
CF	Configuration	IEC 61850 – 7 - 2
CO	Control	IEC 61850 – 7 - 2
DC	Description	IEC 61850 – 7 - 2
EX	Extended Definition	IEC 61850 – 7 - 2
GO	GOOSE Control	IEC 61850 – 7 - 2
GS	GSSE Control (UCA2GOOSE)	IEC 61850 – 7 - 2
LG	Logging	IEC 61850 – 7 - 2
MS	Multicast Sampled Value Control	IEC 61850 – 7 - 2
MX	Measurands (Analogue Values)	IEC 61850 – 7 - 2
RP	Unbuffered Reports	IEC 61850 – 7 - 2
SE	Setting Group Editable	IEC 61850 – 7 - 2
SG	Setting Group	IEC 61850 – 7 - 2
SP	Set Point	IEC 61850 – 7 - 2
ST	Status information	IEC 61850 – 7 - 2
SV	Substitution Values	IEC 61850 – 7 - 2
US	Unicast Sampled Value Control	IEC 61850 – 7 - 2
XX	Data Attribute Service Parameters	IEC 61850 – 7 - 2

Common Data Class: DPL_2_PhyNam

Description: Standard Device Name Plate

CDC Class: DPL

Attribute	Type	FC	Enumeration	Comment	X
vendor	VisString255	DC			
hwRev	VisString255	DC			
swRev	VisString255	DC			
serNum	VisString255	DC			
Model	VisString255	DC			

Common Data Class: INS_2_PhyHealth

Description: Integer status

CDC Class: INS

Attribute	Type	FC	Enumeration	Comment	X
stVal	Enum	ST	PhyHealth		
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: SPS_1_Proxy

Description: Single point status

CDC Class: SPS

Attribute	Type	FC	Enumeration	Comment	X
stVal	BOOLEAN	ST			
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: INC_2_Mod

Description: Controllable integer status

CDC Class: INC

Attribute	Type	FC	Enumeration	Comment	X
stVal	Enum	ST	Mod		
q	Quality	ST			
t	Timestamp	ST			
ctlModel	Enum	CF	ctlModel		

Common Data Class: INC_3_Mod

Description: Controllable integer status

CDC Class: INC

Attribute	Type	FC	Enumeration/Struct	Comment	X
Cancel	Struct	CO	INCCancel_2		
stVal	Enum	ST	Mod		
q	Quality	ST			
t	Timestamp	ST			
ctlModel	Enum	CF	ctlModel		

Common Data Class: INS_1_Beh

Description: Integer status

CDC Class: INS

Attribute	Type	FC	Enumeration	Comment	X
stVal	Enum	ST	Beh		
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: INS_1_Health

Description: Integer status

CDC Class: INS

Attribute	Type	FC	Enumeration	Comment	X
stVal	Enum	ST	Health		
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: LPL_3_NamPlt

Description: Logical node name plate

CDC Class: LPL

Attribute	Type	FC	Enumeration	Comment	X
vendor	VisString255	DC			
swRev	VisString255	DC			
d	VisString255	DC			
configRev	VisString255	DC			
ldNs	VisString255	EX			

Common Data Class: LPL_4_NamPlt

Description: Logical node name plate

CDC Class: LPL

Attribute	Type	FC	Enumeration		X
vendor	VisString255	DC			
swRev	VisString255	DC			
d	VisString255	DC			

Common Data Class: MV_1_TotW

Description: Measured value

CDC Class: MV

Attribute	Type	FC	Enumeration	Comment	X
mag	Struct	MX	AnalogueValue_2		
q	Quality	MX			
t	Timestamp	MX			

Common Data Class: WYE_1_W

Description: Phase to ground related measured values of a three phase system

CDC Class: WYE

Attribute	Type	FC	Enumeration	Comment	X
phsA	CMV_2_phsA				
phsB	CMV_2_phsA				
phsC	CMV_2_phsA				

Common Data Class: WYE_1_Z

Description: Phase to ground related measured values of a three phase system

CDC Class: WYE

Attribute	Type	FC	Enumeration	Comment	X
phsA	CMV_3_phsA				
phsB	CMV_3_phsA				
phsC	CMV_3_phsA				

Common Data Class: SEQ_1_SeqA

Description: Sequence

CDC Class: SEQ

Attribute	Type	FC	Enumeration	Comment	X
c1	CMV_2_phsA				
c2	CMV_2_phsA				
c3	CMV_2_phsA				
seqT	Enim	MX	seqT		

Common Data Class: SEQ_4_SeqA

Description: Sequence

CDC Class: SEQ

Attribute	Type	FC	Enumeration	Comment	X
c1	CMV_3_phsA				
c2	CMV_3_phsA				
c3	CMV_3_phsA				
seqT	Enim	MX	seqT		

Common Data Class: CMV_2_phsA

Description: Complex measured value

CDC Class: CMV

Attribute	Type	FC	Enumeration	Comment	X
cVal	Struct	MX	Vector_3		
q	Quality	MX			
t	Timestamp	MX			

Common Data Class: CMV_3_phsA

Description: Complex measured value

CDC Class: CMV

Attribute	Type	FC	Enumeration	Comment	X
cVal	Struct	MX	Vector_4		
q	Quality	MX			
t	Timestamp	MX			

Common Data Class: ACD_5_Str

Description: Directional protection activation information

CDC Class: ACD

Attribute	Type	FC	Enumeration	Comment	X
general	BOOLEAN	ST			
dirGeneral	Enum	ST	dirGeneral		
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: ACD_2_Str

Description: Directional protection activation information

CDC Class: ACD

Attribute	Type	FC	Enumeration	Comment	X
general	BOOLEAN	ST			
dirGeneral	Enum	ST	dirGeneral		
phsA	BOOLEAN	ST			
dirPhsA	Enum	ST	dirPhs		
phsB	BOOLEAN	ST			
dirPhsB	Enum	ST	dirPhs		
phsC	BOOLEAN	ST			
dirPhsC	Enum	ST	dirPhs		

q	Quality	ST			
t	Timestamp	ST			

Common Data Class: ACT_1_Op

Description: Protection activation information

CDC Class: ACT

Attribute	Type	FC	Enumeration	Comment	X
general	BOOLEAN	ST			
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: ACT_5_Op

Description: Protection activation information

CDC Class: ACT

Attribute	Type	FC	Enumeration	Comment	X
general	BOOLEAN	ST			
phsA	BOOLEAN	ST			
phsB	BOOLEAN	ST			
phsC	BOOLEAN	ST			
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: ACT_6_Op

Description: Protection activation information

CDC Class: ACT

Attribute	Type	FC	Enumeration	Comment	X
general	BOOLEAN	ST			
phsA	BOOLEAN	ST			
phsB	BOOLEAN	ST			
phsC	BOOLEAN	ST			
neut	BOOLEAN	ST			
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: INS_1_AutoRecSt

Description: Integer status

CDC Class:INS

Attribute	Type	FC	Enumeration	Comment	X
stVal	Enum	ST	AutoRecSt		
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: INS_1_Intin

Description: Integer status

CDC Class:INS

Attribute	Type	FC	Enumeration	Comment	X
stVal	INT32	ST			
q	Quality	ST			
t	Timestamp	ST			

Common Data Class:SPC_2_RcdTrg

Description: Controllable single point

CDC Class:SPC

Attribute	Type	FC	Enumeration	Comment	X
stVal	BOOLEAN	ST	t		
q	Quality	ST			
t	Timestamp	ST			
ctlModel	Enum	CF	ctlModel		

Common Data Attribute Type definitions

Common data attribute types, known herein as components, are defined for use in the Common Data Classes defined in the sections above.

Component: INCCancel_2

Comment: Controllable integer status

Attribute	Type	Structure	Comment	X
ctlVal	INT32			
origin	Struct		Originator_2	
ctlNum	INT8U			
T	Timestamp			
Test	BOOLEAN			

Component: Vector_3

Comment: Complex Vector (w.r.t. Floating Point Magnitude and Angle values)

Parent Type: Vector

Attribute	Type	Structure	Comment	X
mag	Struct	AnalogueValue_2	The magnitude of the complex value	

Component: Vector_4

Comment: Complex Vector (w.r.t. Floating Point Magnitude and Angle values)

Parent Type: Vector

Attribute	Type	Structure	Comment	X
mag	Struct	AnalogueValue_2	The magnitude of the complex value	
ang	Struct	AnalogueValue_2	The angle of the complex value (the unit is degrees)	

Component: AnalogueValue_2

Comment: General Analogue Value (w.r.t. Floating Point Value)

Parent **Type**: AnalogueValue

Attribute	Type	Enumeration	Comment	X
f	FLOAT32		Floating point value	

Component: Originator_2

Comment: Originator Value

Parent Type: Originator

Attribute	Type	Enumeration	Comment	X
orCat	Enum	orCat		
orIdent	Octet64			

Enumerated Type Definitions

The following sub-sections specify the enumerations that are associated to some Common Data Class attributes. The definition of the enumerations is according to IEC 61850-7-3 and IEC 61850-7-4 unless otherwise stated.

Enumerated type: AutoRecSt

Description: Auto-Reclose Status

Ordinal	Semantic
1	Ready
2	InProgress
3	Successful
4	WaitingForTrip
5	TripFromProtection
6	FaultDisappeared
7	WaitToComplete
8	CBclosed
9	CycleUnsuccessful
10	Unsuccessful
11	Aborted

Enumerated type: Beh

Description: Behaviour

Ordinal	Semantic
1	on
2	blocked
3	test
4	test/blocked
5	off

Enumerated type: Mod

Description: Mode

Ordinal	Semantic
1	on
2	blocked
3	test
4	test/blocked
5	off

Enumerated type: Health

Description: Health

Ordinal	Semantic
1	Ok
2	Warning
3	Alarm

Enumerated type: PhyHealth

Description: Health

Ordinal	Semantic
1	Ok
2	Warning
3	Alarm

Enumerated type: dirGeneral

Description: Direction

Ordinal	Semantic
0	unknown
1	forward
2	backward
3	both

Enumerated type: dirPhs

Description: Direction

Ordinal	Semantic
0	unknown
1	forward
2	backward

Enumerated type: ctlModel

Description: Control Model

Ordinal	Semantic
0	status-only
1	direct-with-normal-security
2	sbo-with-normal-security
3	direct-with-enhanced-security
4	sbo-with-enhanced-security

Enumerated type: orCat

Description: Originator Category

Ordinal	Semantic
0	not-supported
1	bay-control
2	station-control
3	remote-control
4	Automatic-bay
5	Automatic-station
6	automatic-remote
7	maintenance
8	process

Enumerated type: seqT

Description: Originator Category

Ordinal	Semantic
0	pos-neg-zero
1	dir-quad-zero

N.3 Data Mapping Specifications

L-PRO Logical Device

L-PRO logical device identifications

L-PRO 4000 has the following IEC 61850 logical devices defined in its ICD file:

- Measurements
- FaultData
- Protection
- System
- VirtualInputs

L-PRO logical nodes

Table N.19: L-PRO Logical Nodes defines the list of logical nodes (LN) for the L-PRO logical devices.

Note:

System logical nodes (group L) are not shown here

Table N.19: L-PRO Logical Nodes

LD Name	LN Name	LN Description	Protection Function	Comments
Measure-ments	MAINMMXU1	Measurement		Main channel metering data: • Total Active Power; • Total Reactive Power; • Total Apparent Power; • Average Power Factor; • Frequency; • Phase voltages; • Phase currents ; • Phase active power; • Phase reactive power; • Phase apparent power; • Phase power factor; • Phase impedances.
Measure-ments	MAINMSQI1	Measurement		Main channel sequence voltage and current
Measure-ments	AUXMMXU2	Measurement		Auxiliary channel metering data: • Phase voltages; • Phase currents.
FaultData	D21N1MMXU6	Measurement	21N1	Zone 1 21N fault frequency, voltages and currents

FaultData	D21N1MSQI1	Measurement	21N1	Zone 1 21N fault Zero Sequence current
FaultData	D21N1RFLO6	Fault Locator	21N1	Zone 1 21N fault locator
FaultData	D21N2MMXU7	Measurement	21N2	Zone 2 21N fault frequency, voltages and currents
FaultData	D21N2MSQI2	Measurement	21N2	Zone 2 21N fault Zero Sequence current
FaultData	D21N2RFLO7	Fault Locator	21N2	Zone 2 21N fault locator
FaultData	D21N3MMXU16	Measurement	21N3	Zone 3 21N fault frequency, voltages and currents
FaultData	D21N3MSQI3	Measurement	21N3	Zone 3 21N fault Zero Sequence current
FaultData	D21N3RFLO8	Fault Locator	21N3	Zone 3 21N fault locator
FaultData	D21N4MMXU17	Measurement	21N4	Zone 4 21N fault frequency, voltages and currents
FaultData	D21N4MSQI4	Measurement	21N4	Zone 4 21N fault Zero Sequence current
FaultData	D21N4RFLO9	Fault Locator	21N4	Zone 4 21N fault locator
FaultData	D21N5MMXU10	Measurement	21N5	Zone 5 21N fault frequency, voltages and currents
FaultData	D21N5MSQI5	Measurement	21N5	Zone 5 21N fault Zero Sequence current
FaultData	D21N5RFLO10	Fault Locator	21N5	Zone 5 21N fault locator
FaultData	D21P1MMXU1	Measurement	21P1	Zone 1 21P fault frequency, voltages and currents
FaultData	D21P1RFLO1	Fault Locator	21P1	Zone 1 21P fault locator
FaultData	D21P2MMXU2	Measurement	21P2	Zone 2 21P fault frequency, voltages and currents
FaultData	D21P2RFLO2	Fault Locator	21P2	Zone 2 21P fault locator
FaultData	D21P3MMXU3	Measurement	21P3	Zone 3 21P fault frequency, voltages and currents
FaultData	D21P3RFLO3	Fault Locator	21P3	Zone 3 21P fault locator
FaultData	D21P4MMXU4	Measurement	21P4	Zone 4 21P fault frequency, voltages and currents
FaultData	D21P4RFLO4	Fault Locator	21P4	Zone 4 21P fault locator
FaultData	D21P5MMXU5	Measurement	21P5	Zone 5 21P fault frequency, voltages and currents
FaultData	D21P5RFLO5	Fault Locator	21P5	Zone 5 21P fault locator
FaultData	D27AMMXU15	Measurement	27	27 Auxiliary fault voltages
FaultData	D27MMMXU14	Measurement	27	27 Main fault voltages
FaultData	D4650MSQI7	Measurement	46/50	46/50 Negative Sequence overcurrent
FaultData	D4651MSQI10	Measurement	46/51	46/51 Negative Sequence overcurrent
FaultData	D50LSAMMXU9	Measurement	50LS	50LS Auxiliary fault currents
FaultData	D50LSMMMXU8	Measurement	50LS	50LS Main fault currents
FaultData	D5067MMXU18	Measurement	50/67	50/67 fault currents

FaultData	D50N67MSQI8	Measurement	50N/67	50N/67 Zero Sequence current
FaultData	D5167MMXU19	Measurement	51/67	51/67 fault currents
FaultData	D51N67MSQI9	Measurement	51N/67	51N/67 Zero Sequence current
FaultData	D59A2MMXU21	Measurement	59-1	59-1 Auxiliary fault voltages
FaultData	D59AMMXU13	Measurement	59-2	59-2 Auxiliary fault voltages
FaultData	D59MMMXU12	Measurement	59-1	59-1 Main fault voltages
FaultData	D59M2MMXU20	Measurement	59-2	59-2 Main fault voltages
FaultData	DSCHMMXU11	Measurement		Distance scheme fault frequency, voltages and currents
FaultData	DSCHMSQI6	Measurement		Distance scheme Zero Sequence current
FaultData	DSCHRFLO11	Measurement		Distance scheme fault locator
Protection	CBFIRBRF5	Breaker failure	BFI	Breaker Failure Initiation
Protection	D21P1PDIS1	Distance	21P1	Zone 1 phase
Protection	D21P2PDIS2	Distance	21P2	Zone 2 phase
Protection	D21P3PDIS3	Distance	21P3	Zone 3 phase
Protection	D21P4PDIS4	Distance	21P4	Zone 4 phase
Protection	D21P5PDIS5	Distance	21P5	Zone 5 phase
Protection	D21N1PDIS7	Distance	21N1	Zone 1 ground
Protection	D21N2PDIS8	Distance	21N2	Zone 2 ground
Protection	D21N3PDIS9	Distance	21N3	Zone 3 ground
Protection	D21N4PDIS10	Distance	21N4	Zone 4 ground
Protection	D21N5PDIS11	Distance	21N5	Zone 5 ground
Protection	LodEncPDIS6	Distance	Load Encroachment	Load Encroachment Block
Protection	D2527RSYN1	Synchronism-check or synchronising		25/27/59 Sync Check
Protection	D27AuxPTUV2	Undervoltage	27	27 Auxiliary Trip
Protection	D27MnPTUV1	Undervoltage	27	27 Main Trip
Protection	D50BF1RBRF1	Breaker failure	50BF	Main 1 Trip
Protection	D50BF2RBRF2	Breaker failure	50BF	Main 2 Trip
Protection	D50BF3RBRF3	Breaker failure	50BF	Auxiliary 1 Trip
Protection	D50BF4RBRF4	Breaker failure	50BF	Auxiliary 2 Trip
Protection	D50LS1PIOC1	Instantaneous Over-current	50LS	50LS Main Trip
Protection	D50LS2PIOC2	Instantaneous Over-current	50LS	50LS Auxiliary Trip

Protection	D50PIOC3	Instantaneous Over-current	50	50 Trip
Protection	D50NPIOC4	Instantaneous Over-current	50N	50N Trip
Protection	D46_50PIOC5	Instantaneous Over-current	46/50	46/50 Trip and Alarm
Protection	D51PTOC1	Time Overcurrent	51	51 Trip and Alarm
Protection	D51NPTOC2	Time Overcurrent	51N	51N Trip and Alarm
Protection	D46_51PTOC3	Time Overcurrent	46/51	46/51 Trip and Alarm
Protection	D59MPTOV1	Overvoltage	59	59-1 Main Trip
Protection	D59M2PTOV3	Overvoltage	59	59-2 Main Trip
Protection	D59APTOV2	Overvoltage	59	59-1 Auxiliary Trip
Protection	D59A2PTOV4	Overvoltage	59	59-2 Auxiliary Trip
Protection	D59NPTOV5	Overvoltage	59N Inverse	59N Inverse Trip and Alarm
Protection	DTLPTOV6	Overvoltage	59N Definite Time Delay	59N Definite Time Delay Trip and Alarm
Protection	D68TrRPSB1	Power swing detection/blocking	68	68 Power swing Trip
Protection	D68B1RPSB2	Power swing detection/blocking	68-1	Zone 1 68 Power swing Trip/Block
Protection	D68B2RPSB3	Power swing detection/blocking	68-2	Zone 2 68 Power swing Trip/Block
Protection	D68B3RPSB4	Power swing detection/blocking	68-3	Zone 3 68 Power swing Trip/Block
Protection	D68B4RPSB5	Power swing detection/blocking	68-4	Zone 4 68 Power swing Trip
Protection	D68B5RPSB6	Power swing detection/blocking	68-5	Zone 5 68 Power swing Trip
Protection	D79MRREC1	Auto reclosing	79	Main Auto reclose
Protection	D79ARREC2	Auto reclosing	79	Auxiliary Auto reclose
Protection	D81_1PFRC1	Rate of change of frequency	81-1	81-1 rate of change of frequency Trip
Protection	D81_2PFRC2	Rate of change of frequency	81-2	81-2 rate of change of frequency Trip
Protection	D81_3PFRC3	Rate of change of frequency	81-3	81-3 rate of change of frequency Trip
Protection	D81_4PFRC4	Rate of change of frequency	81-4	81-4 rate of change of frequency Trip
Protection	D81_1PTOF1	Overfrequency	81-1	81-1 overfrequency Trip
Protection	D81_2PTOF2	Overfrequency	81-2	81-2 overfrequency Trip
Protection	D81_3PTOF3	Overfrequency	81-3	81-3 overfrequency Trip
Protection	D81_4PTOF4	Overfrequency	81-4	81-4 overfrequency Trip

Protection	D81_1PTUF1	Underfrequency	81-1	81-1 underfrequency Trip
Protection	D81_2PTUF2	Underfrequency	81-2	81-2 underfrequency Trip
Protection	D81_3PTUF3	Underfrequency	81-3	81-3 underfrequency Trip
Protection	D81_4PTUF4	Underfrequency	81-4	81-4 underfrequency Trip
Protection	DEFSchPSCH2	Protection scheme	DEF Scheme	DEF Scheme Send/Trip
Protection	DisSchPSCH1	Protection scheme	Distance Scheme	Distance Scheme Send/Trip
Protection	PTFuseGGIO6	Generic process I/O		PT Fuse Failure operation
Protection	CTSGGIO7		60CTS	60CTS status
Protection	SOTFGGIO8	Generic process I/O	SOTF	SOTF Trip
System	PLGGIO1	Generic process I/O		ProLogic functions from 1 through 24
System	SGGGIO2	Generic process I/O		Active setting group
System	EIGGIO3	Generic process I/O		External Inputs from 1 through 20
System	OCGGIO4	Generic process I/O		Output Contacts from 1 through 21
System	SChAlmGGIO5	Generic process I/O		SelfCheck Fail Alarm
System	LEDGGIO10	Generic process I/O		Front Panel LED state Target from 1 through 11; ALARM; SERVICE REQUIRED
System	TSAlmGGIO12	Generic process I/O		Time Synchronization Alarm
System	VIGGIO13	Generic process I/O		Virtual Inputs from 1 through 30
VirtualInputs	SUBSCRGGIO1	Generic process I/O		External GOOSE Virtual Inputs from 1 through 30

Logical Node Specifications

The following sections provide detailed spec information on the L-PRO logical device and logical nodes as defined in the Table N.19 “L-PRO Logical Nodes”.

Measurement Logical Device

MAINMMXU1

This section defines logical node data for the logical node MAINMMXU1.

Data Name	Description
MAINMMXU1MXPhV$phsA$cValmagf	Line voltage phase A magnitude
MAINMMXU1MXPhV$phsA$cValangf	Line voltage phase A angle
MAINMMXU1MXPhV$phsB$cValmagf	Line voltage phase B magnitude
MAINMMXU1MXPhV$phsB$cValangf	Line voltage phase B angle
MAINMMXU1MXPhV$phsC$cValmagf	Line voltage phase C magnitude
MAINMMXU1MXPhV$phsC$cValangf	Line voltage phase C angle
MAINMMXU1MXA$phsA$cValmagf	Line current phase A magnitude
MAINMMXU1MXA$phsA$cValangf	Line current phase A angle
MAINMMXU1MXA$phsB$cValmagf	Line current phase B magnitude
MAINMMXU1MXA$phsB$cValangf	Line current phase B angle
MAINMMXU1MXA$phsC$cValmagf	Line current phase C magnitude
MAINMMXU1MXA$phsC$cValangf	Line current phase C angle
MAINMMXU1MXW$phsA$cValmagf	Phase A active power
MAINMMXU1MXW$phsB$cValmagf	Phase B active power
MAINMMXU1MXW$phsC$cValmagf	Phase C active power
MAINMMXU1MXVAr$phsA$cValmagf	Phase A reactive power
MAINMMXU1MXVAr$phsB$cValmagf	Phase B reactive power
MAINMMXU1MXVAr$phsC$cValmagf	Phase C reactive power
MAINMMXU1MXVA$phsA$cValmagf	Phase A apparent power
MAINMMXU1MXVA$phsB$cValmagf	Phase B apparent power
MAINMMXU1MXVA$phsC$cValmagf	Phase C apparent power
MAINMMXU1MXPF$phsA$cValmagf	Phase A power factor
MAINMMXU1MXPF$phsB$cValmagf	Phase B power factor
MAINMMXU1MXPF$phsC$cValmagf	Phase C power factor
MAINMMXU1MXZ$phsA$cValmagf	Impedance phase A magnitude
MAINMMXU1MXZ$phsA$cValangf	Impedance phase A angle
MAINMMXU1MXZ$phsB$cValmagf	Impedance phase B magnitude

MAINMMXU1MXZ$phsB$cValangf	Impedance phase B angle
MAINMMXU1MXZ$phsC$cValmagf	Impedance phase C magnitude
MAINMMXU1MXZ$phsC$cValangf	Impedance phase C angle
MAINMMXU1MXTotWmagf	Total Active Power
MAINMMXU1MXTotVArmagf	Total Reactive Power
MAINMMXU1MXTotVAmagf	Total Apparent Power
MAINMMXU1MXTotPFmagf	Average Power Factor
MAINMMXU1MXHzmagf	Frequency

AUXMMXU2

This section defines logical node data for the logical node AUXMMXU2.

Data Name	Description
AUXMMXU2MXPhV$phsA$cValmagf	Bus voltage phase A magnitude
AUXMMXU2MXPhV$phsA$cValangf	Bus voltage phase A angle
AUXMMXU2MXPhV$phsB$cValmagf	Bus voltage phase B magnitude
AUXMMXU2MXPhV$phsB$cValangf	Bus voltage phase B angle
AUXMMXU2MXPhV$phsC$cValmagf	Bus voltage phase C magnitude
AUXMMXU2MXPhV$phsC$cValangf	Bus voltage phase C angle
AUXMMXU2MXA$phsA$cValmagf	Current 2 phase A magnitude
AUXMMXU2MXA$phsA$cValangf	Current 2 phase A angle
AUXMMXU2MXA$phsB$cValmagf	Current 2 phase B magnitude
AUXMMXU2MXA$phsB$cValangf	Current 2 phase B angle
AUXMMXU2MXA$phsC$cValmagf	Current 2 phase C magnitude
AUXMMXU2MXA$phsC$cValangf	Current 2 phase C angle

MAINMSQI1

This section defines logical node data for the logical node MAINMSQI1.

Data Name	Description
MAINMSQI1MXSeqA$c1$cValmagf	Positive sequence current (I1)
MAINMSQI1MXSeqA$c2$cValmagf	Negative sequence current (I2)
MAINMSQI1MXSeqA$c3$cValmagf	Zero Sequence current (I0)
MAINMSQI1MXSeqA$seqT	Set to “pos-neg-zero”
MAINMSQI1MXSeqV$c1$cValmagf	Positive sequence voltage (V1)
MAINMSQI1MXSeqV$c2$cValmagf	Negative sequence voltage (V2)
MAINMSQI1MXSeqV$c3$cValmagf	Zero Sequence voltage (V0)
MAINMSQI1MXSeqA$seqT	Set to “pos-neg-zero”

FaultData Logical Device

D21P1MMXU1

This section defines logical node data for the logical node D21P1MMXU1.

Data Name	Description
D21P1MMXU1MXHzmagf	21P1 fault frequency
D21P1MMXU1MXPhV$phsA$cValmagf	21P1 phase A fault voltage magnitude
D21P1MMXU1MXPhV$phsA$cValangf	21P1 phase A voltage angle
D21P1MMXU1MXPhV$phsB$cValmagf	21P1 phase B fault voltage magnitude
D21P1MMXU1MXPhV$phsB$cValangf	21P1 phase B fault voltage angle
D21P1MMXU1MXPhV$phsC$cValmagf	21P1 phase C fault voltage magnitude
D21P1MMXU1MXPhV$phsC$cValangf	21P1 phase C fault voltage angle
D21P1MMXU1MXA$phsA$cValmagf	21P1 phase A fault current magnitude
D21P1MMXU1MXA$phsA$cValangf	21P1 phase A fault current angle
D21P1MMXU1MXA$phsB$cValmagf	21P1 phase B fault current magnitude
D21P1MMXU1MXA$phsB$cValangf	21P1 phase B fault current angle
D21P1MMXU1MXA$phsC$cValmagf	21P1 phase C fault current magnitude
D21P1MMXU1MXA$phsC$cValangf	21P1 phase C fault current angle

D21P2MMXU2

This section defines logical node data for the logical node D21P2MMXU2.

Data Name	Description
D21P2MMXU2MXHzmagf	21P2 fault frequency
D21P2MMXU2MXPhV$phsA$cValmagf	21P2 phase A fault voltage magnitude
D21P2MMXU2MXPhV$phsA$cValangf	21P2 phase A voltage angle
D21P2MMXU2MXPhV$phsB$cValmagf	21P2 phase B fault voltage magnitude
D21P2MMXU2MXPhV$phsB$cValangf	21P2 phase B fault voltage angle
D21P2MMXU2MXPhV$phsC$cValmagf	21P2 phase C fault voltage magnitude
D21P2MMXU2MXPhV$phsC$cValangf	21P2 phase C fault voltage angle
D21P2MMXU2MXA$phsA$cValmagf	21P2 phase A fault current magnitude
D21P2MMXU2MXA$phsA$cValangf	21P2 phase A fault current angle
D21P2MMXU2MXA$phsB$cValmagf	21P2 phase B fault current magnitude
D21P2MMXU2MXA$phsB$cValangf	21P2 phase B fault current angle
D21P2MMXU2MXA$phsC$cValmagf	21P2 phase C fault current magnitude
D21P2MMXU2MXA$phsC$cValangf	21P2 phase C fault current angle

D21P3MMXU3

This section defines logical node data for the logical node D21P3MMXU3.

Data Name	Description
D21P3MMXU3MXHzmagf	21P3 fault frequency
D21P3MMXU3MXPhV$phsA$cValmagf	21P3 phase A fault voltage magnitude
D21P3MMXU3MXPhV$phsA$cValangf	21P3 phase A voltage angle
D21P3MMXU3MXPhV$phsB$cValmagf	21P3 phase B fault voltage magnitude
D21P3MMXU3MXPhV$phsB$cValangf	21P3 phase B fault voltage angle
D21P3MMXU3MXPhV$phsC$cValmagf	21P3 phase C fault voltage magnitude
D21P3MMXU3MXPhV$phsC$cValangf	21P3 phase C fault voltage angle
D21P3MMXU3MXA$phsA$cValmagf	21P3 phase A fault current magnitude
D21P3MMXU3MXA$phsA$cValangf	21P3 phase A fault current angle
D21P3MMXU3MXA$phsB$cValmagf	21P3 phase B fault current magnitude
D21P3MMXU3MXA$phsB$cValangf	21P3 phase B fault current angle

D21P3MMXU3MXA$phsC$cValmagf	21P3 phase C fault current magnitude
D21P3MMXU3MXA$phsC$cValangf	21P3 phase C fault current angle

D21P4MMXU4

This section defines logical node data for the logical node D21P4MMXU4.

Data Name	Description
D21P4MMXU4MXHzmagf	21P4 fault frequency
D21P4MMXU4MXPhV$phsA$cValmagf	21P4 phase A fault voltage magnitude
D21P4MMXU4MXPhV$phsA$cValangf	21P4 phase A voltage angle
D21P4MMXU4MXPhV$phsB$cValmagf	21P4 phase B fault voltage magnitude
D21P4MMXU4MXPhV$phsB$cValangf	21P4 phase B fault voltage angle
D21P4MMXU4MXPhV$phsC$cValmagf	21P4 phase C fault voltage magnitude
D21P4MMXU4MXPhV$phsC$cValangf	21P4 phase C fault voltage angle
D21P4MMXU4MXA$phsA$cValmagf	21P4 phase A fault current magnitude
D21P4MMXU4MXA$phsA$cValangf	21P4 phase A fault current angle
D21P4MMXU4MXA$phsB$cValmagf	21P4 phase B fault current magnitude
D21P4MMXU4MXA$phsB$cValangf	21P4 phase B fault current angle
D21P4MMXU4MXA$phsC$cValmagf	21P4 phase C fault current magnitude
D21P4MMXU4MXA$phsC$cValangf	21P4 phase C fault current angle

D21P5MMXU5

This section defines logical node data for the logical node D21P5MMXU5.

Data Name	Description
D21P5MMXU5MXHzmagf	21P5 fault frequency
D21P5MMXU5MXPhV$phsA$cValmagf	21P5 phase A fault voltage magnitude
D21P5MMXU5MXPhV$phsA$cValangf	21P5 phase A voltage angle
D21P5MMXU5MXPhV$phsB$cValmagf	21P5 phase B fault voltage magnitude
D21P5MMXU5MXPhV$phsB$cValangf	21P5 phase B fault voltage angle
D21P5MMXU5MXPhV$phsC$cValmagf	21P5 phase C fault voltage magnitude
D21P5MMXU5MXPhV$phsC$cValangf	21P5 phase C fault voltage angle
D21P5MMXU5MXA$phsA$cValmagf	21P5 phase A fault current magnitude

D21P5MMXU5MXA$phsA$cValangf	21P5 phase A fault current angle
D21P5MMXU5MXA$phsB$cValmagf	21P5 phase B fault current magnitude
D21P5MMXU5MXA$phsB$cValangf	21P5 phase B fault current angle
D21P5MMXU5MXA$phsC$cValmagf	21P5 phase C fault current magnitude
D21P5MMXU5MXA$phsC$cValangf	21P5 phase C fault current angle

D21N1MMXU6

This section defines logical node data for the logical node D21N1MMXU6.

Data Name	Description
D21N1MMXU6MXHzmagf	21N1 fault frequency
D21N1MMXU6MXPhV$phsA$cValmagf	21N1 Main phase A fault voltage magnitude
D21N1MMXU6MXPhV$phsA$cValangf	21N1 Main phase A voltage angle
D21N1MMXU6MXPhV$phsB$cValmagf	21N1 Main phase B fault voltage magnitude
D21N1MMXU6MXPhV$phsB$cValangf	21N1 Main phase B fault voltage angle
D21N1MMXU6MXPhV$phsC$cValmagf	21N1 Main phase C fault voltage magnitude
D21N1MMXU6MXPhV$phsC$cValangf	21N1 Main phase C fault voltage angle
D21N1MMXU6MXA$phsA$cValmagf	21N1 Line phase A fault current magnitude
D21N1MMXU6MXA$phsA$cValangf	21N1 Line phase A fault current angle
D21N1MMXU6MXA$phsB$cValmagf	21N1 Line phase B fault current magnitude
D21N1MMXU6MXA$phsB$cValangf	21N1 Line phase B fault current angle
D21N1MMXU6MXA$phsC$cValmagf	21N1 Line phase C fault current magnitude
D21N1MMXU6MXA$phsC$cValangf	21N1 Line phase C fault current angle

D21N2MMXU7

This section defines logical node data for the logical node D21N2MMXU7.

Data Name	Description
D21N2MMXU7MXHzmagf	21N2 fault frequency
D21N2MMXU7MXPhV$phsA$cValmagf	21N2 Main phase A fault voltage magnitude
D21N2MMXU7MXPhV$phsA$cValangf	21N2 Main phase A voltage angle
D21N2MMXU7MXPhV$phsB$cValmagf	21N2 Main phase B fault voltage magnitude
D21N2MMXU7MXPhV$phsB$cValangf	21N2 Main phase B fault voltage angle
D21N2MMXU7MXPhV$phsC$cValmagf	21N2 Main phase C fault voltage magnitude
D21N2MMXU7MXPhV$phsC$cValangf	21N2 Main phase C fault voltage angle
D21N2MMXU7MXA$phsA$cValmagf	21N2 Line phase A fault current magnitude
D21N2MMXU7MXA$phsA$cValangf	21N2 Line phase A fault current angle
D21N2MMXU7MXA$phsB$cValmagf	21N2 Line phase B fault current magnitude
D21N2MMXU7MXA$phsB$cValangf	21N2 Line phase B fault current angle
D21N2MMXU7MXA$phsC$cValmagf	21N2 Line phase C fault current magnitude
D21N2MMXU7MXA$phsC$cValangf	21N2 Line phase C fault current angle

D50LSMMMXU8

This section defines logical node data for the logical node D50LSMMMXU8.

Data Name	Description
D50LSMMMXU8MXA$phsA$cValmagf	50LS Main phase A fault current magnitude
D50LSMMMXU8MXA$phsA$cValangf	50LS Main phase A fault current angle
D50LSMMMXU8MXA$phsB$cValmagf	50LS Main phase B fault current magnitude
D50LSMMMXU8MXA$phsB$cValangf	50LS Main phase B fault current angle
D50LSMMMXU8MXA$phsC$cValmagf	50LS Main phase C fault current magnitude
D50LSMMMXU8MXA$phsC$cValangf	50LS Main phase C fault current angle

D50LSAMMXU9

This section defines logical node data for the logical node D50LSAMMXU9.

Data Name	Description
D50LSAMMXU9MXA$phsA$cValmagf	50LS Auxiliary phase A fault current magnitude
D50LSAMMXU9MXA$phsA$cValangf	50LS Auxiliary phase A fault current angle
D50LSAMMXU9MXA$phsB$cValmagf	50LS Auxiliary phase B fault current magnitude
D50LSAMMXU9MXA$phsB$cValangf	50LS Auxiliary phase B fault current angle
D50LSAMMXU9MXA$phsC$cValmagf	50LS Auxiliary phase C fault current magnitude
D50LSAMMXU9MXA$phsC$cValangf	50LS Auxiliary phase C fault current angle

D21N5MMXU10

This section defines logical node data for the logical node D21N5MMXU10.

Data Name	Description
D21N5MMXU10MXHzmagf	21N5 fault frequency
D21N5MMXU10MXPhV$phsA$cValmagf	21N5 phase A fault voltage magnitude
D21N5MMXU10MXPhV$phsA$cValangf	21N5 phase A voltage angle
D21N5MMXU10MXPhV$phsB$cValmagf	21N5 phase B fault voltage magnitude
D21N5MMXU10MXPhV$phsB$cValangf	21N5 phase B fault voltage angle
D21N5MMXU10MXPhV$phsC$cValmagf	21N5 phase C fault voltage magnitude
D21N5MMXU10MXPhV$phsC$cValangf	21N5 phase C fault voltage angle
D21N5MMXU10MXA$phsA$cValmagf	21N5 phase A fault current magnitude
D21N5MMXU10MXA$phsA$cValangf	21N5 phase A fault current angle
D21N5MMXU10MXA$phsB$cValmagf	21N5 phase B fault current magnitude
D21N5MMXU10MXA$phsB$cValangf	21N5 phase B fault current angle
D21N5MMXU10MXA$phsC$cValmagf	21N5 phase C fault current magnitude
D21N5MMXU10MXA$phsC$cValangf	21N5 phase C fault current angle

DSCHMMXU11

This section defines logical node data for the logical node DSCHMMXU11.

Data Name	Description
DSCHMMXU11MXHzmagf	Distance Scheme fault frequency
DSCHMMXU11MXPhV$phsA$cValmagf	Distance Scheme phase A fault voltage magnitude
DSCHMMXU11MXPhV$phsA$cValangf	Distance Scheme phase A voltage angle
DSCHMMXU11MXPhV$phsB$cValmagf	Distance Scheme phase B fault voltage magnitude
DSCHMMXU11MXPhV$phsB$cValangf	Distance Scheme phase B fault voltage angle
DSCHMMXU11MXPhV$phsC$cValmagf	Distance Scheme phase C fault voltage magnitude
DSCHMMXU11MXPhV$phsC$cValangf	Distance Scheme phase C fault voltage angle
DSCHMMXU11MXA$phsA$cValmagf	Distance Scheme phase A fault current magnitude
DSCHMMXU11MXA$phsA$cValangf	Distance Scheme phase A fault current angle
DSCHMMXU11MXA$phsB$cValmagf	Distance Scheme phase B fault current magnitude
DSCHMMXU11MXA$phsB$cValangf	Distance Scheme phase B fault current angle
DSCHMMXU11MXA$phsC$cValmagf	Distance Scheme phase C fault current magnitude
DSCHMMXU11MXA$phsC$cValangf	Distance Scheme phase C fault current angle

D59MMMXU12

This section defines logical node data for the logical node D59MMMXU12.

Data Name	Description
D59MMMXU12MXPhV$phsA$cValmagf	59-1 Main phase A fault voltage magnitude
D59MMMXU12MXPhV$phsA$cValangf	59-1 Main phase A voltage angle
D59MMMXU12MXPhV$phsB$cValmagf	59-1 Main phase B fault voltage magnitude
D59MMMXU12MXPhV$phsB$cValangf	59-1 Main phase B fault voltage angle
D59MMMXU12MXPhV$phsC$cValmagf	59-1 Main phase C fault voltage magnitude
D59MMMXU12MXPhV$phsC$cValangf	59-1 Main phase C fault voltage angle

D59AMMXU13

This section defines logical node data for the logical node D59AMMXU13.

Data Name	Description
D59AMMXU13MXPhV$phsA$cValmagf	59-1 Auxiliary phase A fault voltage magnitude
D59AMMXU13MXPhV$phsA$cValangf	59-1 Auxiliary phase A voltage angle
D59AMMXU13MXPhV$phsB$cValmagf	59-1 Auxiliary phase B fault voltage magnitude
D59AMMXU13MXPhV$phsB$cValangf	59-1 Auxiliary phase B fault voltage angle
D59AMMXU13MXPhV$phsC$cValmagf	59-1 Auxiliary phase C fault voltage magnitude
D59AMMXU13MXPhV$phsC$cValangf	59-1 Auxiliary phase C fault voltage angle

D27MMMXU14

This section defines logical node data for the logical node D27MMMXU14.

Data Name	Description
D27MMMXU14MXPhV$phsA$cValmagf	27 Main phase A fault voltage magnitude
D27MMMXU14MXPhV$phsA$cValangf	27 Main phase A voltage angle
D27MMMXU14MXPhV$phsB$cValmagf	27 Main phase B fault voltage magnitude
D27MMMXU14MXPhV$phsB$cValangf	27 Main phase B fault voltage angle
D27MMMXU14MXPhV$phsC$cValmagf	27 Main phase C fault voltage magnitude
D27MMMXU14MXPhV$phsC$cValangf	27 Main phase C fault voltage angle

D27AMMXU15

This section defines logical node data for the logical node D27AMMXU15.

Data Name	Description
D27AMMXU15MXPhV$phsA$cValmagf	27 Auxiliary phase A fault voltage magnitude
D27AMMXU15MXPhV$phsA$cValangf	27 Auxiliary phase A voltage angle
D27AMMXU15MXPhV$phsB$cValmagf	27 Auxiliary phase B fault voltage magnitude
D27AMMXU15MXPhV$phsB$cValangf	27 Auxiliary phase B fault voltage angle
D27AMMXU15MXPhV$phsC$cValmagf	27 Auxiliary phase C fault voltage magnitude
D27AMMXU15MXPhV$phsC$cValangf	27 Auxiliary phase C fault voltage angle

D21N3MMXU16

This section defines logical node data for the logical node D21N3MMXU16.

Data Name	Description
D21N3MMXU16MXHzmagf	21N3 fault frequency
D21N3MMXU16MXPhV$phsA$cValmagf	21N3 phase A fault voltage magnitude
D21N3MMXU16MXPhV$phsA$cValangf	21N3 phase A voltage angle
D21N3MMXU16MXPhV$phsB$cValmagf	21N3 phase B fault voltage magnitude
D21N3MMXU16MXPhV$phsB$cValangf	21N3 phase B fault voltage angle
D21N3MMXU16MXPhV$phsC$cValmagf	21N3 phase C fault voltage magnitude
D21N3MMXU16MXPhV$phsC$cValangf	21N3 phase C fault voltage angle
D21N3MMXU16MXA$phsA$cValmagf	21N3 phase A fault current magnitude
D21N3MMXU16MXA$phsA$cValangf	21N3 phase A fault current angle
D21N3MMXU16MXA$phsB$cValmagf	21N3 phase B fault current magnitude
D21N3MMXU16MXA$phsB$cValangf	21N3 phase B fault current angle
D21N3MMXU16MXA$phsC$cValmagf	21N3 phase C fault current magnitude
D21N3MMXU16MXA$phsC$cValangf	21N3 phase C fault current angle

D21N4MMXU17

This section defines logical node data for the logical node D21N4MMXU17.

Data Name	Description
D21N4MMXU17MXHzmagf	21N4 fault frequency
D21N4MMXU17MXPhV$phsA$cValmagf	21N4 phase A fault voltage magnitude
D21N4MMXU17MXPhV$phsA$cValangf	21N4 phase A voltage angle
D21N4MMXU17MXPhV$phsB$cValmagf	21N4 phase B fault voltage magnitude
D21N4MMXU17MXPhV$phsB$cValangf	21N4 phase B fault voltage angle
D21N4MMXU17MXPhV$phsC$cValmagf	21N4 phase C fault voltage magnitude
D21N4MMXU17MXPhV$phsC$cValangf	21N4 phase C fault voltage angle
D21N4MMXU17MXA$phsA$cValmagf	21N4 phase A fault current magnitude
D21N4MMXU17MXA$phsA$cValangf	21N4 phase A fault current angle
D21N4MMXU17MXA$phsB$cValmagf	21N4 phase B fault current magnitude
D21N4MMXU17MXA$phsB$cValangf	21N4 phase B fault current angle

D21N4MMXU17MXA$phsC$cValmagf	21N4 phase C fault current magnitude
D21N4MMXU17MXA$phsC$cValangf	21N4 phase C fault current angle

D5067MMXU18

This section defines logical node data for the logical node D5067MMXU18.

Data Name	Description
D5067MMXU18MXA$phsA$cValmagf	50/67 phase A fault current magnitude
D5067MMXU18MXA$phsA$cValangf	50/67 phase A fault current angle
D5067MMXU18MXA$phsB$cValmagf	50/67 phase B fault current magnitude
D5067MMXU18MXA$phsB$cValangf	50/67 phase B fault current angle
D5067MMXU18MXA$phsC$cValmagf	50/67 phase C fault current magnitude
D5067MMXU18MXA$phsC$cValangf	50/67 phase C fault current angle

D5167MMXU19

This section defines logical node data for the logical node D5167MMXU19.

Data Name	Description
D5167MMXU19MXA$phsA$cValmagf	51/67 phase A fault current magnitude
D5167MMXU19MXA$phsA$cValangf	51/67 phase A fault current angle
D5167MMXU19MXA$phsB$cValmagf	51/67 phase B fault current magnitude
D5167MMXU19MXA$phsB$cValangf	51/67 phase B fault current angle
D5167MMXU19MXA$phsC$cValmagf	51/67 phase C fault current magnitude
D5167MMXU19MXA$phsC$cValangf	51/67 phase C fault current angle

D59M2MMXU20

This section defines logical node data for the logical node D59M2MMXU20.

Data Name	Description
D59M2MMXU20MXPhV$phsA$cValmagf	59-2 Main phase A fault voltage magnitude
D59M2MMXU20MXPhV$phsA$cValangf	59-2 Main phase A voltage angle
D59M2MMXU20MXPhV$phsB$cValmagf	59-2 Main phase B fault voltage magnitude
D59M2MMXU20MXPhV$phsB$cValangf	59-2 Main phase B fault voltage angle
D59M2MMXU20MXPhV$phsC$cValmagf	59-2 Main phase C fault voltage magnitude
D59M2MMXU20MXPhV$phsC$cValangf	59-2 Main phase C fault voltage angle

D59A2MMXU21

This section defines logical node data for the logical node D59A2MMXU21.

Data Name	Description
D59A2MMXU21MXPhV$phsA$cValmagf	59-2 Auxiliary phase A fault voltage magnitude
D59A2MMXU21MXPhV$phsA$cValangf	59-2 Auxiliary phase A voltage angle
D59A2MMXU21MXPhV$phsB$cValmagf	59-2 Auxiliary phase B fault voltage magnitude
D59A2MMXU21MXPhV$phsB$cValangf	59-2 Auxiliary phase B fault voltage angle
D59A2MMXU21MXPhV$phsC$cValmagf	59-2 Auxiliary phase C fault voltage magnitude
D59A2MMXU21MXPhV$phsC$cValangf	59-2 Auxiliary phase C fault voltage angle

D21N1MSQI1

This section defines logical node data for the logical node D21N1MSQI1.

Data Name	Description
D21N1MSQI1MXSeqA$c1$cValmagf	Not mapped
D21N1MSQI1MXSeqA$c1$cValangf	Not mapped
D21N1MSQI1MXSeqA$c2$cValmagf	Not mapped
D21N1MSQI1MXSeqA$c2$cValangf	Not mapped
D21N1MSQI1MXSeqA$c3$cValmagf	21N1 Line Zero Sequence current magnitude
D21N1MSQI1MXSeqA$c3$cValangf	21N1 Line Zero Sequence current angle

D21N1MSQI1MXSeqA$seqT	Not mapped
D21N1MSQI1MXSeqV$c1$cValmagf	Not mapped
D21N1MSQI1MXSeqV$c1$cValangf	Not mapped
D21N1MSQI1MXSeqV$c2$cValmagf	Not mapped
D21N1MSQI1MXSeqV$c2$cValangf	Not mapped
D21N1MSQI1MXSeqV$c3$cValmagf	21N1 Main Zero Sequence voltage magnitude
D21N1MSQI1MXSeqV$c3$cValangf	21N1 Main Zero Sequence voltage angle
D21N1MSQI1MXSeqV$seqT	Not mapped

D21N2MSQI2

This section defines logical node data for the logical node D21N2MSQI2.

Data Name	Description
D21N2MSQI2MXSeqA$c1$cValmagf	Not mapped
D21N2MSQI2MXSeqA$c1$cValangf	Not mapped
D21N2MSQI2MXSeqA$c2$cValmagf	Not mapped
D21N2MSQI2MXSeqA$c2$cValangf	Not mapped
D21N2MSQI2MXSeqA$c3$cValmagf	21N2 Line Zero Sequence current magnitude
D21N2MSQI2MXSeqA$c3$cValangf	21N2 Line Zero Sequence current angle
D21N2MSQI2MXSeqA$seqT	Not mapped
D21N2MSQI2MXSeqV$c1$cValmagf	Not mapped
D21N2MSQI2MXSeqV$c1$cValangf	Not mapped
D21N2MSQI2MXSeqV$c2$cValmagf	Not mapped
D21N2MSQI2MXSeqV$c2$cValangf	Not mapped
D21N2MSQI2MXSeqV$c3$cValmagf	21N2 Main Zero Sequence voltage magnitude
D21N2MSQI2MXSeqV$c3$cValangf	21N2 Main Zero Sequence voltage angle
D21N2MSQI2MXSeqV$seqT	Not mapped

D21N3MSQI3

This section defines logical node data for the logical node D21N3MSQI3.

Data Name	Description
D21N3MSQI3MXSeqA$c1$cValmagf	Not mapped
D21N3MSQI3MXSeqA$c1$cValangf	Not mapped
D21N3MSQI3MXSeqA$c2$cValmagf	Not mapped
D21N3MSQI3MXSeqA$c2$cValangf	Not mapped
D21N3MSQI3MXSeqA$c3$cValmagf	21N3 Line Zero Sequence current magnitude
D21N3MSQI3MXSeqA$c3$cValangf	21N3 Line Zero Sequence current angle
D21N3MSQI3MXSeqA$seqT	Not mapped
D21N3MSQI3MXSeqV$c1$cValmagf	Not mapped
D21N3MSQI3MXSeqV$c1$cValangf	Not mapped
D21N3MSQI3MXSeqV$c2$cValmagf	Not mapped
D21N3MSQI3MXSeqV$c2$cValangf	Not mapped
D21N3MSQI3MXSeqV$c3$cValmagf	21N3 Main Zero Sequence voltage magnitude
D21N3MSQI3MXSeqV$c3$cValangf	21N3 Main Zero Sequence voltage angle
D21N3MSQI3MXSeqV$seqT	Not mapped

D21N4MSQI4

This section defines logical node data for the logical node D21N4MSQI4.

Data Name	Description
D21N4MSQI4MXSeqA$c1$cValmagf	Not mapped
D21N4MSQI4MXSeqA$c1$cValangf	Not mapped
D21N4MSQI4MXSeqA$c2$cValmagf	Not mapped
D21N4MSQI4MXSeqA$c2$cValangf	Not mapped
D21N4MSQI4MXSeqA$c3$cValmagf	21N4 Line Zero Sequence current magnitude
D21N4MSQI4MXSeqA$c3$cValangf	21N4 Line Zero Sequence current angle
D21N4MSQI4MXSeqA$seqT	Not mapped
D21N4MSQI4MXSeqV$c1$cValmagf	Not mapped
D21N4MSQI4MXSeqV$c1$cValangf	Not mapped
D21N4MSQI4MXSeqV$c2$cValmagf	Not mapped

D21N4MSQI4MXSeqV$c2$cValangf	Not mapped
D21N4MSQI4MXSeqV$c3$cValmagf	21N4 Main Zero Sequence voltage magnitude
D21N3MSQI3MXSeqV$c3$cValangf	21N4 Main Zero Sequence voltage angle
D21N3MSQI3MXSeqV$seqT	Not mapped

D21N5MSQI5

This section defines logical node data for the logical node D21N5MSQI5.

Data Name	Description
D21N5MSQI5MXSeqA$c1$cValmagf	Not mapped
D21N5MSQI5MXSeqA$c1$cValangf	Not mapped
D21N5MSQI5MXSeqA$c2$cValmagf	Not mapped
D21N5MSQI5MXSeqA$c2$cValangf	Not mapped
D21N5MSQI5MXSeqA$c3$cValmagf	21N5 Line Zero Sequence current magnitude
D21N5MSQI5MXSeqA$c3$cValangf	21N5 Line Zero Sequence current angle
D21N5MSQI5MXSeqA$seqT	Not mapped
D21N5MSQI5MXSeqV$c1$cValmagf	Not mapped
D21N5MSQI5MXSeqV$c1$cValangf	Not mapped
D21N5MSQI5MXSeqV$c2$cValmagf	Not mapped
D21N5MSQI5MXSeqV$c2$cValangf	Not mapped
D21N5MSQI5MXSeqV$c3$cValmagf	21N5 Main Zero Sequence voltage magnitude
D21N5MSQI5MXSeqV$c3$cValangf	21N5 Main Zero Sequence voltage angle
D21N5MSQI5MXSeqV$seqT	Not mapped

DSCHMSQI6

This section defines logical node data for the logical node DSCHMSQI6.

Data Name	Description
DSCHMSQI6MXSeqA$c1$cValmagf	Not mapped
DSCHMSQI6MXSeqA$c1$cValangf	Not mapped
DSCHMSQI6MXSeqA$c2$cValmagf	Not mapped
DSCHMSQI6MXSeqA$c2$cValangf	Not mapped
DSCHMSQI6MXSeqA$c3$cValmagf	Distance Scheme Line Zero Sequence current magnitude
DSCHMSQI6MXSeqA$c3$cValangf	Distance Scheme Line Zero Sequence current angle
DSCHMSQI6MXSeqA$seqT	Not mapped
DSCHMSQI6MXSeqV$c1$cValmagf	Not mapped
DSCHMSQI6MXSeqV$c1$cValangf	Not mapped
DSCHMSQI6MXSeqV$c2$cValmagf	Not mapped
DSCHMSQI6MXSeqV$c2$cValangf	Not mapped
DSCHMSQI6MXSeqV$c3$cValmagf	Distance Scheme Main Zero Sequence voltage magnitude
DSCHMSQI6MXSeqV$c3$cValangf	Distance Scheme Main Zero Sequence voltage angle
DSCHMSQI6MXSeqV$seqT	Not mapped

D4650MSQI7

This section defines logical node data for the logical node D4650MSQI7.

Data Name	Description
D4650MSQI7MXSeqA$c1$cValmagf	Not mapped
D4650MSQI7MXSeqA$c1$cValangf	Not mapped
D4650MSQI7MXSeqA$c2$cValmagf	46/50 Line Negative Sequence current magnitude
D4650MSQI7MXSeqA$c2$cValangf	46/50 Line Negative Sequence current angle
D4650MSQI7MXSeqA$c3$cValmagf	Not mapped
D4650MSQI7MXSeqA$c3$cValangf	Not mapped
D4650MSQI7MXSeqA$seqT	Not mapped

D50N67MSQI8

This section defines logical node data for the logical node D50N67MSQI8.

Data Name	Description
D50N67MSQI8MXSeqA$c1$cValmagf	Not mapped
D50N67MSQI8MXSeqA$c1$cValangf	Not mapped
D50N67MSQI8MXSeqA$c2$cValmagf	Not mapped
D50N67MSQI8MXSeqA$c2$cValangf	Not mapped
D50N67MSQI8MXSeqA$c3$cValmagf	50N/67 Line Zero Sequence current magnitude
D50N67MSQI8MXSeqA$c3$cValangf	50N/67 Line Zero Sequence current angle
D50N67MSQI8MXSeqA$seqT	Not mapped

D51N67MSQI9

This section defines logical node data for the logical node D51N67MSQI9.

Data Name	Description
D51N67MSQI9MXSeqA$c1$cValmagf	Not mapped
D51N67MSQI9MXSeqA$c1$cValangf	Not mapped
D51N67MSQI9MXSeqA$c2$cValmagf	Not mapped
D51N67MSQI9MXSeqA$c2$cValangf	Not mapped
D51N67MSQI9MXSeqA$c3$cValmagf	51N/67 Line Zero Sequence current magnitude
D51N67MSQI9MXSeqA$c3$cValangf	51N/67 Line Zero Sequence current angle
D51N67MSQI9MXSeqA$seqT	Not mapped

D4651MSQI10

This section defines logical node data for the logical node D4651MSQI10.

Data Name	Description
D4651MSQI10MXSeqA$c1$cValmagf	Not mapped
D4651MSQI10MXSeqA$c1$cValangf	Not mapped
D4651MSQI10MXSeqA$c2$cValmagf	46/51 Line Negative Sequence current magnitude
D4651MSQI10MXSeqA$c2$cValangf	46/51 Line Negative Sequence current angle
D4651MSQI10MXSeqA$c3$cValmagf	Not mapped
D4651MSQI10MXSeqA$c3$cValangf	Not mapped
D4651MSQI10MXSeqA$seqT	Not mapped

D21P1RFLO1

This section defines logical node data for the logical node D21P1RFLO1.

Data Name	Description
D21P1RFLO1MXFltZ$cVal$mag$f	21P1 fault impedance magnitude
D21P1RFLO1MXFltZ$cVal$ang$f	21P1 fault impedance angle
D21P1RFLO1MXFltDiskmmagf	21P1 fault distance

D21P2RFLO2

This section defines logical node data for the logical node D21P2RFLO2.

Data Name	Description
D21P2RFLO2MXFltZ$cVal$mag$f	21P2 fault impedance magnitude
D21P2RFLO2MXFltZ$cVal$ang$f	21P2 fault impedance angle
D21P2RFLO2MXFltDiskmmagf	21P2 fault distance

D21P3RFLO3

This section defines logical node data for the logical node D21P3RFLO3.

Data Name	Description
D21P3RFLO3MXFltZ$cVal$mag$f	21P3 fault impedance magnitude
D21P3RFLO3MXFltZ$cVal$ang$f	21P3 fault impedance angle
D21P3RFLO3MXFltDiskmmagf	21P3 fault distance

D21P4RFLO4

This section defines logical node data for the logical node D21P4RFLO4.

Data Name	Description
D21P4RFLO4MXFltZ$cVal$mag$f	21P4 fault impedance magnitude
D21P4RFLO4MXFltZ$cVal$ang$f	21P4 fault impedance angle
D21P4RFLO4MXFltDiskmmagf	21P4 fault distance

D21P5RFLO5

This section defines logical node data for the logical node D21P5RFLO5.

Data Name	Description
D21P5RFLO5MXFltZ$cVal$mag$f	21P5 fault impedance magnitude
D21P5RFLO5MXFltZ$cVal$ang$f	21P5 fault impedance angle
D21P5RFLO5MXFltDiskmmagf	21P5 fault distance

D21N1RFLO6

This section defines logical node data for the logical node D21N1RFLO6.

Data Name	Description
D21N1RFLO6MXFltZ$cVal$mag$f	21N1 fault impedance magnitude
D21N1RFLO6MXFltZ$cVal$ang$f	21N1 fault impedance angle
D21N1RFLO6MXFltDiskmmagf	21N1 fault distance

D21N2RFLO7

This section defines logical node data for the logical node D21N2RFLO7.

Data Name	Description
D21N2RFLO7MXFltZ$cVal$mag$f	21N2 fault impedance magnitude
D21N2RFLO7MXFltZ$cVal$ang$f	21N2 fault impedance angle
D21N2RFLO7MXFltDiskmmagf	21N2 fault distance

D21N3RFLO8

This section defines logical node data for the logical node D21N3RFLO8.

Data Name	Description
D21N3RFLO8MXFltZ$cVal$mag$f	21N3 fault impedance magnitude
D21N3RFLO8MXFltZ$cVal$ang$f	21N3 fault impedance angle
D21N3RFLO8MXFltDiskmmagf	21N3 fault distance

D21N4RFLO9

This section defines logical node data for the logical node D21N4RFLO9.

Data Name	Description
D21N4RFLO9MXFltZ$cVal$mag$f	21N4 fault impedance magnitude
D21N4RFLO9MXFltZ$cVal$ang$f	21N4 fault impedance angle
D21N4RFLO9MXFltDiskmmagf	21N4 fault distance

D21N5RFLO10

This section defines logical node data for the logical node D21N5RFLO10.

Data Name	Description
D21N5RFLO10MXFltZ$cVal$mag$f	21N5 fault impedance magnitude
D21N5RFLO10MXFltZ$cVal$ang$f	21N5 fault impedance angle
D21N5RFLO10MXFltDiskmmagf	21N5 fault distance

DSCHRFLO11

This section defines logical node data for the logical node DSCHRFLO11.

Data Name	Description
DSCHRFLO11MXFltZ$cVal$mag$f	Distance Scheme fault impedance magnitude
DSCHRFLO11MXFltZ$cVal$ang$f	Distance Scheme fault impedance angle
DSCHRFLO11MXFltDiskmmagf	Distance Scheme fault distance

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D50BF1RBRF1

This section defines logical node data for the logical node D50BF1RBRF1.

Data Name	Description
D50BF1RBRF1STStr$general	50BF Main 1 Trip
D50BF1RBRF1STStr$dirGeneral	Not mapped (set to “unknown”)
D50BF1RBRF1STOpEx$general	50BF Main 1 Trip

D50BF2RBRF2

This section defines logical node data for the logical node D50BF2RBRF2.

Data Name	Description
D50BF2RBRF2STStr$general	50BF Main 2 Trip
D50BF2RBRF2STStr$dirGeneral	Not mapped (set to “unknown”)
D50BF2RBRF2STOpEx$general	50BF Main 2 Trip

D50BF3RBRF3

This section defines logical node data for the logical node D50BF3RBRF3.

Data Name	Description
D50BF3RBRF3STStr$general	50BF Auxiliary 1 Trip
D50BF3RBRF3STStr$dirGeneral	Not mapped (set to “unknown”)
D50BF3RBRF3STOpEx$general	50BF Auxiliary 1 Trip

D50BF4RBRF4

This section defines logical node data for the logical node D50BF4RBRF4.

Data Name	Description
D50BF4RBRF4STStr$general	50BF Auxiliary 2 Trip
D50BF4RBRF4STStr$dirGeneral	Not mapped (set to “unknown”)
D50BF4RBRF4STOpEx$general	50BF Auxiliary 2 Trip

CBFIRBRF5

This section defines logical node data for the logical node CBFIRBRF5.

Data Name	Description
CBFIRBRF5STStr$general	50BF Initiation
CBFIRBRF5STStr$dirGeneral	Not mapped (set to “unknown”)
CBFIRBRF5STOpEx$general	50BF Initiation

D21P1PDIS1

This section defines logical node data for the logical node D21P1PDIS1.

Data Name	Description
D21P1PDIS1STStr$general	21P1 Trip
D21P1PDIS1STStr$dirGeneral	21P1 Direction (set to “unknown”)
D21P1PDIS1STOp$general	21P1 Trip
D21P1PDIS1STOp$phsA	21P1 Trip phase A
D21P1PDIS1STOp$phsB	21P1 Trip phase B
D21P1PDIS1STOp$phsC	21P1 Trip phase C
D21P1PDIS1STOp$neut	21P1 Trip neutral

D21P2PDIS2

This section defines logical node data for the logical node D21P2PDIS2.

Data Name	Description
D21P2PDIS2STStr$general	21P2 Trip
D21P2PDIS2STStr$dirGeneral	21P2 Direction (set to “unknown”)
D21P2PDIS2STOp$general	21P2 Trip
D21P2PDIS2STOp$phsA	21P2 Trip phase A
D21P2PDIS2STOp$phsB	21P2 Trip phase B
D21P2PDIS2STOp$phsC	21P2 Trip phase C
D21P2PDIS2STOp$neut	21P2 Trip neutral

D21P3PDIS3

This section defines logical node data for the logical node D21P3PDIS3.

Data Name	Description
D21P3PDIS3STStr$general	21P3 Trip
D21P3PDIS3STStr$dirGeneral	21P3 Direction (set to “unknown”)
D21P3PDIS3STOp$general	21P3 Trip
D21P3PDIS3STOp$phsA	21P3 Trip phase A
D21P3PDIS3STOp$phsB	21P3 Trip phase B
D21P3PDIS3STOp$phsC	21P3 Trip phase C
D21P3PDIS3STOp$neut	21P3 Trip neutral

D21P4PDIS4

This section defines logical node data for the logical node D21P4PDIS4.

Data Name	Description
D21P4PDIS4STStr$general	21P4 Trip
D21P4PDIS4STStr$dirGeneral	21P4 Direction (set to “unknown”)
D21P4PDIS4STOp$general	21P4 Trip
D21P4PDIS4STOp$phsA	21P4 Trip phase A
D21P4PDIS4STOp$phsB	21P4 Trip phase B
D21P4PDIS4STOp$phsC	21P4 Trip phase C
D21P4PDIS4STOp$neut	21P4 Trip neutral

D21P5PDIS5

This section defines logical node data for the logical node D21P5PDIS5.

Data Name	Description
D21P5PDIS5STStr$general	21P5 Trip
D21P5PDIS5STStr$dirGeneral	21P5 Direction (set to “unknown”)
D21P5PDIS5STOp$general	21P5 Trip
D21P5PDIS5STOp$phsA	21P5 Trip phase A
D21P5PDIS5STOp$phsB	21P5 Trip phase B
D21P5PDIS5STOp$phsC	21P5 Trip phase C
D21P5PDIS5STOp$neut	21P5 Trip neutral

LodEncPDIS6

This section defines logical node data for the logical node LodEncPDIS6.

Data Name	Description
LodEncPDIS6STStr$general	Load Encroachment Block
LodEncPDIS6STStr$dirGeneral	Load Encroachment Block Direction (set to “unknown”)
LodEncPDIS6STOp$general	Load Encroachment Block

D21N1PDIS7

This section defines logical node data for the logical node D21N1PDIS7.

Data Name	Description
D21N1PDIS7STStr$general	21N1 Trip
D21N1PDIS7STStr$dirGeneral	2NP1 Direction (set to “unknown”)
D21N1PDIS7STOp$general	21N1 Trip
D21N1PDIS7STOp$phsA	21N1 Trip phase A
D21N1PDIS7STOp$phsB	21N1 Trip phase B
D21N1PDIS7STOp$phsC	21N1 Trip phase C

D21N2PDIS8

This section defines logical node data for the logical node D21N2PDIS8.

Data Name	Description
D21N2PDIS8STStr$general	21N2 Trip
D21N2PDIS8STStr$dirGeneral	2NP2 Direction (set to “unknown”)
D21N2PDIS8STOp$general	21N2 Trip
D21N2PDIS8STOp$phsA	21N2 Trip phase A
D21N2PDIS8STOp$phsB	21N2 Trip phase B
D21N2PDIS8STOp$phsC	21N2Trip phase C

D21N3PDIS9

This section defines logical node data for the logical node D21N3PDIS9.

Data Name	Description
D21N3PDIS9STStr$general	21N3 Trip
D21N3PDIS9STStr$dirGeneral	2NP3 Direction (set to “unknown”)
D21N3PDIS9STOp$general	21N3 Trip
D21N3PDIS9STOp$phsA	21N3 Trip phase A
D21N3PDIS9STOp$phsB	21N3 Trip phase B
D21N3PDIS9STOp$phsC	21N3 Trip phase C

D21N4PDIS10

This section defines logical node data for the logical node D21N4PDIS10.

Data Name	Description
D21N4PDIS10STStr$general	21N4 Trip
D21N4PDIS10STStr$dirGeneral	2NP4 Direction (set to “unknown”)
D21N4PDIS10STOp$general	21N4 Trip
D21N4PDIS10STOp$phsA	21N4 Trip phase A
D21N4PDIS10STOp$phsB	21N4 Trip phase B
D21N4PDIS10STOp$phsC	21N4 Trip phase C

D21N5PDIS11

This section defines logical node data for the logical node D21N5PDIS11.

Data Name	Description
D21N5PDIS11STStr$general	21N4 Trip
D21N5PDIS11STStr$dirGeneral	2NP4 Direction (set to “unknown”)
D21N5PDIS11STOp$general	21N4 Trip
D21N5PDIS11STOp$phsA	21N4 Trip phase A
D21N5PDIS11STOp$phsB	21N4 Trip phase B
D21N5PDIS11STOp$phsC	21N4 Trip phase C

D2527RSYN1

This section defines logical node data for the logical node D2527RSYN1.

Data Name	Description
D2527RSYN1STRel$stVal	25/27/59 Sync Check

D27MnPTUV1

This section defines logical node data for the logical node D27MnPTUV1.

Data Name	Description
D27MnPTUV1STStr$general	27 Main Trip
D27MnPTUV1STStr$dirGeneral	27 Main Direction (set to “unknown”)
D27MnPTUV1STOp$general	27 Main Trip
D27MnPTUV1STStr$phsA	27 Main phase A Trip
D27MnPTUV1STStr$dirPhsA	27 Main phase A Direction (set to “unknown”)
D27MnPTUV1STStr$phsB	27 Main phase B Trip
D27MnPTUV1STStr$dirPhsB	27 Main phase B Direction (set to “unknown”)
D27MnPTUV1STStr$phsC	27 Main phase C Trip
D27MnPTUV1STStr$dirPhsC	27 Main phase C Direction (set to “unknown”)

D27AuxPTUV2

This section defines logical node data for the logical node D27AuxPTUV2.

Data Name	Description
D27AuxPTUV2STStr$general	27 Auxiliary Trip
D27AuxPTUV2STStr$dirGeneral	27 Auxiliary Direction (set to “unknown”)
D27AuxPTUV2STOp$general	27 Auxiliary Trip
D27AuxPTUV2STStr$phsA	27 Auxiliary phase A Trip
D27AuxPTUV2STStr$dirPhsA	27 Auxiliary phase A Direction (set to “unknown”)
D27AuxPTUV2STStr$phsB	27 Auxiliary phase B Trip
D27AuxPTUV2STStr$dirPhsB	27 Auxiliary phase B Direction (set to “unknown”)
D27AuxPTUV2STStr$phsC	27 Auxiliary phase C Trip
D27AuxPTUV2STStr$dirPhsC	27 Auxiliary phase C Direction (set to “unknown”)

D50LS1PIOC1

This section defines logical node data for the logical node D50LS1PIOC1.

Data Name	Description
D50LS1PIOC1STOp$general	50LS Main Trip
D50LS1PIOC1STOp$phsA	50LS Main phase A Trip
D50LS1PIOC1STOp$phsB	50LS Main phase B Trip
D50LS1PIOC1STOp$phsC	50LS Main phase C Trip

D50LS2PIOC2

This section defines logical node data for the logical node D50LS2PIOC2.

Data Name	Description
D50LS2PIOC2STOp$general	50LS Auxiliary Trip
D50LS2PIOC2STOp$phsA	50LS Auxiliary phase A Trip
D50LS2PIOC2STOp$phsB	50LS Auxiliary phase B Trip
D50LS2PIOC2STOp$phsC	50LS Auxiliary phase C Trip

D50PIOC3

This section defines logical node data for the logical node D50PIOC3.

Data Name	Description
D50PIOC3STStr$general	50 Trip
D50PIOC3STStr$dirGeneral	50 Trip Direction (set to “unknown”)
D50PIOC3STOp$general	50 Trip
D50PIOC3STOp$phsA	50 Trip phase A Trip
D50PIOC3STOp$phsB	50 Trip phase B Trip
D50PIOC3STOp$phsC	50 Trip phase C Trip

D50NPIOC4

This section defines logical node data for the logical node D50NPIOC4.

Data Name	Description
D50NPIOC4STStr$general	50N Trip
D50NPIOC4STStr$dirGeneral	50N Trip Direction (set to “unknown”)
D50NPIOC4STOp$general	50N Trip

D46_50PIOC5

This section defines logical node data for the logical node D46_50PIOC5.

Data Name	Description
D46_50PIOC5STStr$general	46/50 Trip
D46_50PIOC5STStr$dirGeneral	46/50 Trip Direction (set to “unknown”)
D46_50PIOC5STOp$general	46/50 Trip

D51PTOC1

This section defines logical node data for the logical node D51PTOC1.

Data Name	Description
D51PTOC1STStr$general	51 Alarm
D51PTOC1STStr$dirGeneral	51 Trip Direction (set to “unknown”)
D51PTOC1STOp$general	51 Trip
D51PTOC1STOp$phsA	51 Trip phase A
D51PTOC1STOp$phsB	51 Trip phase B
D51PTOC1STOp$phsC	51 Trip phase C

D51NPTOC2

This section defines logical node data for the logical node D51NPTOC2.

Data Name	Description
D51NPTOC2STStr$general	51N Alarm
D51NPTOC2STStr$dirGeneral	51N Trip Direction (set to “unknown”)
D51NPTOC2STOp$general	51N Trip

D46_51PTOC3

This section defines logical node data for the logical node D46_51PTOC3.

Data Name	Description
D46_51PTOC3STStr$general	46/51 Alarm
D46_51PIOC3STStr$dirGeneral	46/51 Trip Direction (set to “unknown”)
D46_51PTOC3STOp$general	46/51 Trip

D59MPTOV1

This section defines logical node data for the logical node D59MPTOV1.

Data Name	Description
D59MPTOV1STStr$general	59-1 Main Trip
D59MPTOV1STStr$dirGeneral	59-1 Main Trip Direction (set to “unknown”)
D59MPTOV1STStr$phsA	59-1 Main phase A Trip
D59MPTOV1STStr$dirPhsA	59-1 Main phase A Trip Direction (set to “unknown”)
D59MPTOV1STStr$phsB	59-1 Main phase B Trip
D59MPTOV1STStr$dirPhsB	59-1 Main phase B Trip Direction (set to “unknown”)
D59MPTOV1STStr$phsC	59-1 Main phase C Trip
D59MPTOV1STStr$dirPhsC	59-1 Main phase C Trip Direction (set to “unknown”)

D59APTOV2

This section defines logical node data for the logical node D59APTOV2.

Data Name	Description
D59APTOV2STStr$general	59-1 Auxiliary Trip
D59APTOV2STStr$dirGeneral	59-1 Auxiliary Trip Direction (set to “unknown”)
D59APTOV2STStr$phsA	59-1 Auxiliary phase A Trip
D59APTOV2STStr$dirPhsA	59-1 Auxiliary phase A Trip Direction (set to “unknown”)
D59APTOV2STStr$phsB	59-1 Auxiliary phase B Trip
D59APTOV2STStr$dirPhsB	59-1 Auxiliary phase B Trip Direction (set to “unknown”)
D59APTOV2STStr$phsC	59-1 Auxiliary phase C Trip
D59APTOV2STStr$dirPhsC	59-1 Auxiliary phase C Trip Direction (set to “unknown”)

D59M2PTOV3

This section defines logical node data for the logical node D59M2PTOV3.

Data Name	Description
D59M2PTOV3STStr$general	59-2 Main Trip
D59M2PTOV3STStr$dirGeneral	59-2 Main Trip Direction (set to “unknown”)
D59M2PTOV3STStr$phsA	59-2 Main phase A Trip
D59M2PTOV3STStr$dirPhsA	59-2 Main phase A Trip Direction (set to “unknown”)
D59M2PTOV3STStr$phsB	59-2 Main phase B Trip
D59M2PTOV3STStr$dirPhsB	59-2 Main phase B Trip Direction (set to “unknown”)
D59M2PTOV3STStr$phsC	59-2 Main phase C Trip
D59M2PTOV3STStr$dirPhsC	59-2 Main phase C Trip Direction (set to “unknown”)

D59A2PTOV4

This section defines logical node data for the logical node D59A2PTOV4.

Data Name	Description
D59A2PTOV4STStr$general	59-2 Auxiliary Trip
D59A2PTOV4STStr$dirGeneral	59-2 Auxiliary Trip Direction (set to “unknown”)
D59A2PTOV4STStr$phsA	59-2 Auxiliary phase A Trip
D59A2PTOV4STStr$dirPhsA	59-2 Auxiliary phase A Trip Direction (set to “unknown”)
D59A2PTOV4STStr$phsB	59-2 Auxiliary phase B Trip
D59A2PTOV4STStr$dirPhsB	59-2 Auxiliary phase B Trip Direction (set to “unknown”)
D59A2PTOV4STStr$phsC	59-2 Auxiliary phase C Trip
D59A2PTOV4STStr$dirPhsC	59-2 Auxiliary phase C Trip Direction (set to “unknown”)

D59NPTOV5

This section defines logical node data for the logical node D59NPTOV5.

Data Name	Description
D59NPTOV5STStr$general	59N Inverse Alarm
D59NPTOV5STStr$dirGeneral	59N Inverse Trip Direction (set to “unknown”)
D59NPTOV5STOp$general	59N Inverse Trip

DTLPTOV6

This section defines logical node data for the logical node DTLPTOV6.

Data Name	Description
DTLPTOV6STStr$general	59N DEF Alarm
DTLPTOV6STStr$dirGeneral	59N DEF Trip Direction (set to “unknown”)
DTLPTOV6STOp$general	59N DEF Trip

D68TrRPSB1

This section defines logical node data for the logical node D68TrRPSB1.

Data Name	Description
D68TrRPSB1STOp$general	68 Power Swing Trip

D68B1RPSB2

This section defines logical node data for the logical node D68B1RPSB2.

Data Name	Description
D68B1RPSB2STStr$general	68 Power Swing Trip
D68B1RPSB2STStr$dirGeneral	68 Power Swing Direction (set to “unknown”)
D68B1RPSB2STBlkZn$stVal	68 Zone 1 block

D68B2RPSB3

This section defines logical node data for the logical node D68B2RPSB3.

Data Name	Description
D68B2RPSB3STStr$general	68 Power Swing Trip
D68B2RPSB3STStr$dirGeneral	68 Power Swing Direction (set to “unknown”)
D68B2RPSB3STBlkZn$stVal	68 Zone 2 block

D68B3RPSB4

This section defines logical node data for the logical node D68B3RPSB4.

Data Name	Description
D68B3RPSB4STStr$general	68 Power Swing Trip
D68B3RPSB4STStr$dirGeneral	68 Power Swing Direction (set to “unknown”)
D68B3RPSB4STBlkZn$stVal	68 Zone 3 block

D68B4RPSB5

This section defines logical node data for the logical node D68B4RPSB5.

Data Name	Description
D68B4RPSB5STStr$general	68 Power Swing Trip
D68B4RPSB5STStr$dirGeneral	68 Power Swing Direction (set to “unknown”)
D68B4RPSB5STBlkZn$stVal	68 Zone 4 block

D68B5RPSB6

This section defines logical node data for the logical node D68B5RPSB6.

Data Name	Description
D68B5RPSB6STStr$general	68 Power Swing Trip
D68B5RPSB6STStr$dirGeneral	68 Power Swing Direction (set to “unknown”)
D68B5RPSB6STBlkZn$stVal	68 Zone 5 block

D79MRREC1

This section defines logical node data for the logical node D79MRREC1.

Data Name	Description
D79MRREC1STAuto$stVal	79 Main Reclose
D79MRREC1STOp$general	79 Main Reclose
D79MRREC1STAutoRecSt$stVal	79 Main Reclose status change

D79ARREC2

This section defines logical node data for the logical node D79ARREC2.

Data Name	Description
D79ARREC2STAuto$stVal	79 Auxiliary Reclose
D79ARREC2STOp$general	79 Auxiliary Reclose
D79ARREC2STAutoRecSt$stVal	79 Auxiliary Reclose status change

D81_1PFRC1

This section defines logical node data for the logical node D81_1PFRC1.

Data Name	Description
D81_1PFRC1STStr$general	81-1 rate of change of frequency Trip
D81_1PFRC1STStr$dirGeneral	81-1 rate of change of frequency Direction (set to “unknown”)
D81_1PFRC1STOp$general	81-1 rate of change of frequency Trip

D81_2PFRC2

This section defines logical node data for the logical node D81_2PFRC2.

Data Name	Description
D81_2PFRC2STStr$general	81-2 rate of change of frequency Trip
D81_2PFRC2STStr$dirGeneral	81-2 rate of change of frequency Direction (set to “unknown”)
D81_2PFRC2STOp$general	81-2 rate of change of frequency Trip

D81_3PFRC3

This section defines logical node data for the logical node D81_3PFRC3.

Data Name	Description
D81_3PFRC3STStr$general	81-3 rate of change of frequency Trip
D81_3PFRC3STStr$dirGeneral	81-3 rate of change of frequency Direction (set to “unknown”)
D81_3PFRC3STOp$general	81-3 rate of change of frequency Trip

D81_4PFRC4

This section defines logical node data for the logical node D81_4PFRC4.

Data Name	Description
D81_4PFRC4STStr$general	81-4 rate of change of frequency Trip
D81_4PFRC4STStr$dirGeneral	81-4 rate of change of frequency Direction (set to “unknown”)
D81_4PFRC4STOp$general	81-4 rate of change of frequency Trip

D81_1PTOF1

This section defines logical node data for the logical node D81_1PTOF1.

Data Name	Description
D81_1PTOF1STStr$general	81-1 Overfrequency Trip
D81_1PTOF1STStr$dirGeneral	81-1 Overfrequency Direction (set to “unknown”)
D81_1PTOF1STOp$general	81-1 Overfrequency Trip

D81_2PTOF2

This section defines logical node data for the logical node D81_2PTOF2.

Data Name	Description
D81_2PTOF2STStr$general	81-2 Overfrequency Trip
D81_2PTOF2STStr$dirGeneral	81-2 Overfrequency Direction (set to “unknown”)
D81_2PTOF2STOp$general	81-2 Overfrequency Trip

D81_3PTOF3

This section defines logical node data for the logical node D81_3PTOF3.

Data Name	Description
D81_3PTOF3STStr$general	81-3 Overfrequency Trip
D81_3PTOF3STStr$dirGeneral	81-3 Overfrequency Direction (set to “unknown”)
D81_3PTOF3STOp$general	81-3 Overfrequency Trip

D81_4PTOF4

This section defines logical node data for the logical node D81_4PTOF4.

Data Name	Description
D81_4PTOF4STStr$general	81-4 Overfrequency Trip
D81_4PTOF4STStr$dirGeneral	81-4 Overfrequency Direction (set to “unknown”)
D81_4PTOF4STOp$general	81-4 Overfrequency Trip

D81_1PTUF1

This section defines logical node data for the logical node D81_1PTUF1.

Data Name	Description
D81_1PTUF1STStr$general	81-1 Underfrequency Trip
D81_1PTUF1STStr$dirGeneral	81-1 Underfrequency Direction (set to “unknown”)
D81_1PTUF1STOp$general	81-1 Underfrequency Trip

D81_2PTUF2

This section defines logical node data for the logical node D81_2PTUF2.

Data Name	Description
D81_2PTUF2STStr$general	81-2 Underfrequency Trip
D81_2PTUF2STStr$dirGeneral	81-2 Underfrequency Direction (set to “unknown”)
D81_2PTUF2STOp$general	81-2 Underfrequency Trip

D81_3PTUF3

This section defines logical node data for the logical node D81_3PTUF3.

Data Name	Description
D81_3PTUF3STStr$general	81-3 Underfrequency Trip
D81_3PTUF3STStr$dirGeneral	81-3 Underfrequency Direction (set to “unknown”)
D81_3PTUF3STOp$general	81-3 Underfrequency Trip

D81_4PTUF4

This section defines logical node data for the logical node D81_4PTUF4.

Data Name	Description
D81_4PTUF4STStr$general	81-4 Underfrequency Trip
D81_4PTUF4STStr$dirGeneral	81-4 Underfrequency Direction (set to “unknown”)
D81_4PTUF4STOp$general	81-4 Underfrequency Trip

DisSchPSCH1

This section defines logical node data for the logical node DisSchPSCH1.

Data Name	Description
DisSchPSCH1STProTx$stVal	Set to “FALSE”
DisSchPSCH1STProRx$stVal	Distance Scheme Received
DisSchPSCH1STStr$general	Distance Scheme Send
DisSchPSCH1STStr$dirGeneral	Distance Scheme Send Direction (set to “unknown”)
DisSchPSCH1STOp$general	Distance Scheme Trip
DisSchPSCH1STWeiOp$general	Distance Scheme Weak Infeed Trip

DEFSchPSCH2

This section defines logical node data for the logical node DEFSchPSCH2.

Data Name	Description
DEFSchPSCH2STProTx$stVal	Set to “FALSE”
DEFSchPSCH2STProRx$stVal	DEF Scheme Received
DEFSchPSCH2STStr$general	DEF Scheme Send
DEFSchPSCH2STStr$dirGeneral	DEF Scheme Send Direction (set to “unknown”)
DEFSchPSCH2STOp$general	DEF Scheme Trip

PTFuseGGIO6

This section defines logical node data for the logical node PTFuseGGIO6.

Data Name	Description
PTFuseGGIO6STInd$stVal	60 Alarm

CTSGGIO7

This section defines logical node data for the logical node CTSGGIO7.

Data Name	Description
CTSGGIO7STInd1$stVal	60 CTS Main
CTSGGIO7STInd2$stVal	60 CTS Auxiliary

SOTFGGIO8

This section defines logical node data for the logical node SOTFGGIO8.

Data Name	Description
SOTFGGIO8STInd$stVal	SOTF Trip

System Logical Device

PLGGIO1

This section defines logical node data for the logical node PLGGIO1.

Data Name	Description
PLGGIO1STInd1$stVal	ProLogic 1
PLGGIO1STInd2$stVal	ProLogic 2
PLGGIO1STInd3$stVal	ProLogic 3
PLGGIO1STInd4$stVal	ProLogic 4
PLGGIO1STInd5$stVal	ProLogic 5
PLGGIO1STInd6$stVal	ProLogic 6
PLGGIO1STInd7$stVal	ProLogic 7
PLGGIO1STInd8$stVal	ProLogic 8
PLGGIO1STInd9$stVal	ProLogic 9
PLGGIO1STInd10$stVal	ProLogic 10
PLGGIO1STInd11$stVal	ProLogic 11
PLGGIO1STInd12$stVal	ProLogic 12
PLGGIO1STInd13$stVal	ProLogic 13
PLGGIO1STInd14$stVal	ProLogic 14
PLGGIO1STInd15$stVal	ProLogic 15
PLGGIO1STInd16$stVal	ProLogic 16
PLGGIO1STInd17$stVal	ProLogic 17
PLGGIO1STInd18$stVal	ProLogic 18
PLGGIO1STInd19$stVal	ProLogic 19
PLGGIO1STInd20$stVal	ProLogic 20
PLGGIO1STInd21$stVal	ProLogic 21
PLGGIO1STInd22$stVal	ProLogic 22
PLGGIO1STInd23$stVal	ProLogic 23
PLGGIO1STInd24$stVal	ProLogic 24

SGGGIO2

This section defines logical node data for the logical node SGGGIO2.

Data Name	Description
SGGGIO2STIntIn$stVal	Active Settings Group

EIGGIO3

This section defines logical node data for the logical node EIGGIO3.

Data Name	Description
EIGGIO3STInd1$stVal	External Input 1
EIGGIO3STInd2$stVal	External Input 2
EIGGIO3STInd3$stVal	External Input 3
EIGGIO3STInd4$stVal	External Input 4
EIGGIO3STInd5$stVal	External Input 5
EIGGIO3STInd6$stVal	External Input 6
EIGGIO3STInd7$stVal	External Input 7
EIGGIO3STInd8$stVal	External Input 8
EIGGIO3STInd9$stVal	External Input 9
EIGGIO3STInd10$stVal	External Input 10
EIGGIO3STInd11$stVal	External Input 11
EIGGIO3STInd12$stVal	External Input 12
EIGGIO3STInd13$stVal	External Input 13
EIGGIO3STInd14$stVal	External Input 14
EIGGIO3STInd15$stVal	External Input 15
EIGGIO3STInd16$stVal	External Input 16
EIGGIO3STInd17$stVal	External Input 17
EIGGIO3STInd18$stVal	External Input 18
EIGGIO3STInd19$stVal	External Input 19
EIGGIO3STInd20$stVal	External Input 20

OCGGIO4

This section defines logical node data for the logical node OCGGIO4.

Data Name	Description
OCGGIO4STInd1$stVal	Output Contact 1
OCGGIO4STInd2$stVal	Output Contact 2
OCGGIO4STInd3$stVal	Output Contact 3
OCGGIO4STInd4$stVal	Output Contact 4
OCGGIO4STInd5$stVal	Output Contact 5
OCGGIO4STInd6$stVal	Output Contact 6
OCGGIO4STInd7$stVal	Output Contact 7
OCGGIO4STInd8$stVal	Output Contact 8
OCGGIO4STInd9$stVal	Output Contact 9
OCGGIO4STInd10$stVal	Output Contact 10
OCGGIO4STInd11$stVal	Output Contact 11
OCGGIO4STInd12$stVal	Output Contact 12
OCGGIO4STInd13$stVal	Output Contact 13
OCGGIO4STInd14$stVal	Output Contact 14
OCGGIO4STInd15$stVal	Output Contact 15
OCGGIO4STInd16$stVal	Output Contact 16
OCGGIO4STInd17$stVal	Output Contact 17
OCGGIO4STInd18$stVal	Output Contact 18
OCGGIO4STInd19$stVal	Output Contact 19
OCGGIO4STInd20$stVal	Output Contact 20
OCGGIO4STInd21$stVal	Output Contact 21

SChAlmGGIO5

This section defines logical node data for the logical node SChAlmGGIO5.

Data Name	Description
SChAlmGGIO5STInd$stVal	Self Check Fail Alarm

LEDGGIO10

This section defines logical node data for the logical node LEDGGIO10of the logical device System.

Data Name	Description
LEDGGIO10STInd1$stVal	Target LED 1 State
LEDGGIO10STInd2$stVal	Target LED 2 State
LEDGGIO10STInd3$stVal	Target LED 3 State
LEDGGIO10STInd4$stVal	Target LED 4 State
LEDGGIO10STInd5$stVal	Target LED 5 State
LEDGGIO10STInd6$stVal	Target LED 6 State
LEDGGIO10STInd7$stVal	Target LED 7 State
LEDGGIO10STInd8$stVal	Target LED 8 State
LEDGGIO10STInd9$stVal	Target LED 9 State
LEDGGIO10STInd10$stVal	Target LED 10 State
LEDGGIO10STInd11$stVal	Target LED 11 state
LEDGGIO10STInd12$stVal	Alarm LED state
LEDGGIO10STInd13$stVal	Service Required LED state

TSAlmGGIO12

This section defines logical node data for the logical node TSAlmGGIO12.

Data Name	Description
TSAlmGGIO12STInd$stVal	Time Synchronization Alarm

VIGGIO13

This section defines logical node data for the logical node VIGGIO13.

Data Name	Description
VIGGIO13STInd1$stVal	Virtual Input 1
VIGGIO13STInd2$stVal	Virtual Input 2
VIGGIO13STInd3$stVal	Virtual Input 3
VIGGIO13STInd4$stVal	Virtual Input 4
VIGGIO13STInd5$stVal	Virtual Input 5
VIGGIO13STInd6$stVal	Virtual Input 6
VIGGIO13STInd7$stVal	Virtual Input 7
VIGGIO13STInd8$stVal	Virtual Input 8
VIGGIO13STInd9$stVal	Virtual Input 9
VIGGIO13STInd10$stVal	Virtual Input 10
VIGGIO13STInd11$stVal	Virtual Input 11
VIGGIO13STInd12$stVal	Virtual Input 12
VIGGIO13STInd13$stVal	Virtual Input 13
VIGGIO13STInd14$stVal	Virtual Input 14
VIGGIO13STInd15$stVal	Virtual Input 15
VIGGIO13STInd16$stVal	Virtual Input 16
VIGGIO13STInd17$stVal	Virtual Input 17
VIGGIO13STInd18$stVal	Virtual Input 18
VIGGIO13STInd19$stVal	Virtual Input 19
VIGGIO13STInd20$stVal	Virtual Input 20
VIGGIO13STInd21$stVal	Virtual Input 21
VIGGIO13STInd22$stVal	Virtual Input 22
VIGGIO13STInd23$stVal	Virtual Input 23
VIGGIO13STInd24$stVal	Virtual Input 24
VIGGIO13STInd25$stVal	Virtual Input 25
VIGGIO13STInd26$stVal	Virtual Input 26
VIGGIO13STInd27$stVal	Virtual Input 27
VIGGIO13STInd28$stVal	Virtual Input 28
VIGGIO13STInd29$stVal	Virtual Input 29
VIGGIO13STInd30$stVal	Virtual Input 30

VirtaulInputs Logical Device

SUBSCRGGIO1

This section defines logical node data for the logical node SUBSCRGGIO1.

Data Name	Description
SUBSCRGGIO1STInd1$stVal	Subscribed GOOSE Virtual Input 1
SUBSCRGGIO1STInd2$stVal	Subscribed GOOSE Virtual Input 2
SUBSCRGGIO1STInd3$stVal	Subscribed GOOSE Virtual Input 3
SUBSCRGGIO1STInd4$stVal	Subscribed GOOSE Virtual Input 4
SUBSCRGGIO1STInd5$stVal	Subscribed GOOSE Virtual Input 5
SUBSCRGGIO1STInd6$stVal	Subscribed GOOSE Virtual Input 6
SUBSCRGGIO1STInd7$stVal	Subscribed GOOSE Virtual Input 7
SUBSCRGGIO1STInd8$stVal	Subscribed GOOSE Virtual Input 8
SUBSCRGGIO1STInd9$stVal	Subscribed GOOSE Virtual Input 9
SUBSCRGGIO1STInd10$stVal	Subscribed GOOSE Virtual Input 10
SUBSCRGGIO1STInd11$stVal	Subscribed GOOSE Virtual Input 11
SUBSCRGGIO1STInd12$stVal	Subscribed GOOSE Virtual Input 12
SUBSCRGGIO1STInd13$stVal	Subscribed GOOSE Virtual Input 13
SUBSCRGGIO1STInd14$stVal	Subscribed GOOSE Virtual Input 14
SUBSCRGGIO1STInd15$stVal	Subscribed GOOSE Virtual Input 15
SUBSCRGGIO1STInd16$stVal	Subscribed GOOSE Virtual Input 16
SUBSCRGGIO1STInd17$stVal	Subscribed GOOSE Virtual Input 17
SUBSCRGGIO1STInd18$stVal	Subscribed GOOSE Virtual Input 18
SUBSCRGGIO1STInd19$stVal	Subscribed GOOSE Virtual Input 19
SUBSCRGGIO1STInd20$stVal	Subscribed GOOSE Virtual Input 20
SUBSCRGGIO1STInd21$stVal	Subscribed GOOSE Virtual Input 21
SUBSCRGGIO1STInd22$stVal	Subscribed GOOSE Virtual Input 22
SUBSCRGGIO1STInd23$stVal	Subscribed GOOSE Virtual Input 23
SUBSCRGGIO1STInd24$stVal	Subscribed GOOSE Virtual Input 24
SUBSCRGGIO1STInd25$stVal	Subscribed GOOSE Virtual Input 25
SUBSCRGGIO1STInd26$stVal	Subscribed GOOSE Virtual Input26
SUBSCRGGIO1STInd27$stVal	Subscribed GOOSE Virtual Input 27
SUBSCRGGIO1STInd28$stVal	Subscribed GOOSE Virtual Input 28
SUBSCRGGIO1STInd29$stVal	Subscribed GOOSE Virtual Input 29
SUBSCRGGIO1STInd30$stVal	Subscribed GOOSE Virtual Input 30

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